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Fig. 1. *Nat. Size.*

Moss-form Gold in Quartz. a, a and b, b Secondary Quartz Veins.

Fig. 2. *Gold Thread magnified, to show shaky character.*

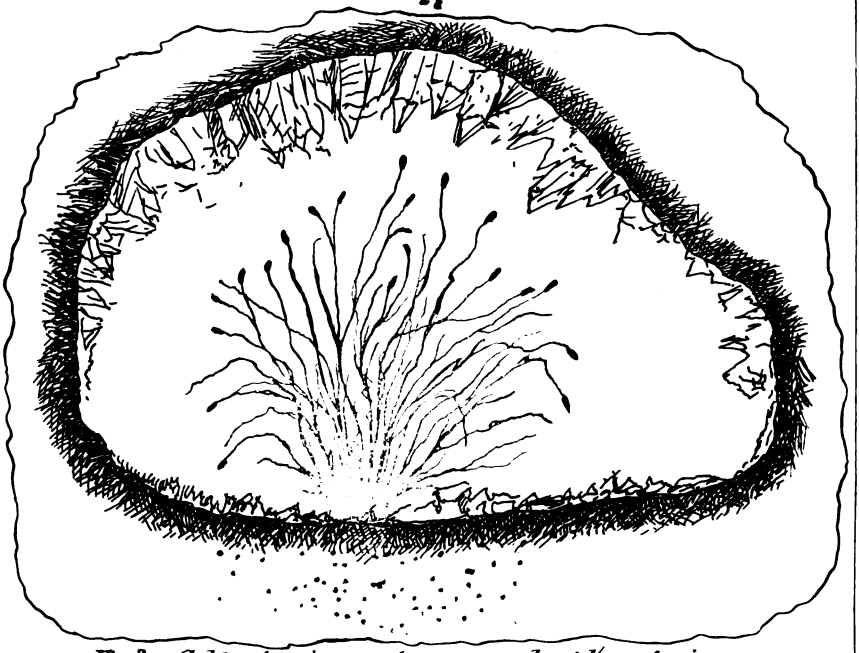

Fig. 3. Golden tree in quartz cavern about ½ nat. size.

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Mineralogical Magazine

AND

JOURNAL

OF THE

MINERALOGICAL SOCIETY

OF

GREAT BRITAIN AND IRELAND.

VOLUME III.

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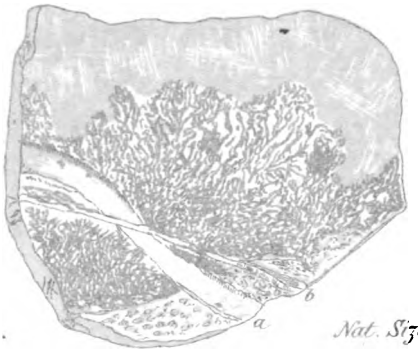

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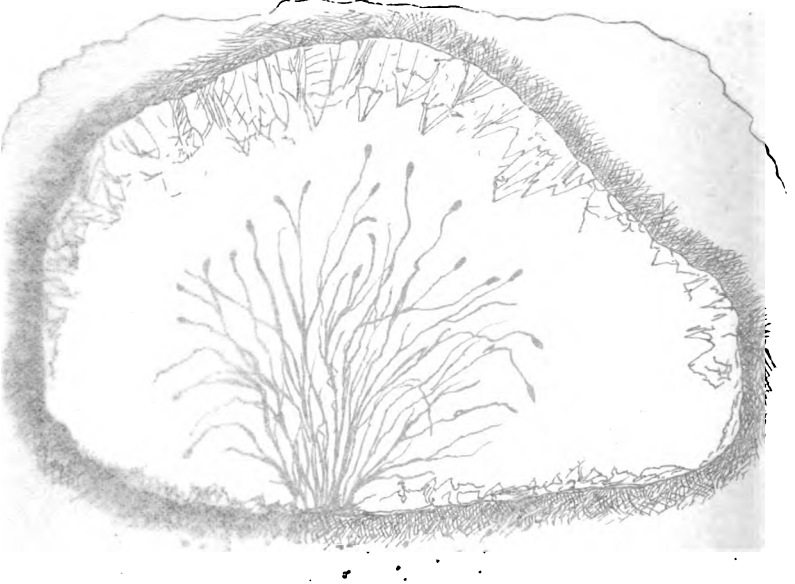
Fig. 2. *Gold Thread magnified. to show sheety character.*



Quartz carrn about ½ nat. size.

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THE MINERALOGICAL MAGAZINE

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MINERALOGICAL SOCIETY OF GREAT BRITAIN AND IRELAND

No. 13. APRIL, 1879. Vol. III.

I.—*Contributions towards a History of British Meteorites.*

By Townshend M. Hall, F.G.S., &c.

As the rare descent of Meteorites or Aërolites affords us the only real tangible evidence we possess respecting the mineral constituents which exist beyond the limits of our own globe, a great degree of interest must always be attached to these stray visitors; and although much has been written on the subject at different times, it has hitherto taken the form either of a bare catalogue of the date and place of occurrence; or of scattered notices dealing only with individual cases. My desire is to collect these various records as far as they relate to each meteoric stone which has been known, or has been said to have fallen in Great Britain, and to endeavour to give as complete an account as possible of every instance; including not only the historical facts, but also notices of mineralogical observations and references to authorities.

In collecting the evidence as to the fall of a meteoric stone, it is highly important to obtain the following particulars:—

1. The exact date and place of the occurrence.
2. The number and weight of the stones.
3. External appearance.
4. Chemical composition and specific gravity.
5. In what Museum or private collection the stone or stones have been deposited.
6. References to any published accounts.

Though an answer to all the above questions would be sufficient for mineralogical purposes, there are many other facts bearing upon the subject

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which unfortunately are frequently overlooked in published descriptions. For example, it would be interesting to ascertain to what depth the stone penetrated, and in what soil. Whether hot when found. Whether it descended in a cloudless sky, or during a storm; and if a meteor was seen, to note its direction, and whether it exploded before reaching the earth. The accompanying noise, if any, should also be described.

In no single instance have I been able to obtain satisfactory answers to all these particulars; and in some cases, indeed, only the bare fact seems to have been recorded that a stone fell on such a date, and at such a place. Of the stones themselves some have been irrecoverably lost, others have found their way into foreign museums, and some are in the possession of private individuals.

In dealing with long periods of time, and a large area of country, anyone who has attempted to collect evidence regarding an event which took place even a few years ago, must be aware how exceedingly difficult is the task of separating truth from error. My purpose, as I have said before, is to collect everything that is known on the subject of British Meteorites; to establish by means of copious references every fact relative to each recorded fall; and to inquire into all doubtful instances, so as to ascertain, if possible, whether their authenticity can be proved, and to expunge them from the list if they can be shewn to be the results of errors.

The doubtful instances of meteoric falls may be classed under four general heads:—

1st. A meteor has been seen apparently to fall, and a search has been made where it seemed to descend. The results of these searches have included nodules of pyrite, fragments of scoriæ, hematite, and ordinary pebbles, all distinctly terrestial, but which have been described as "Meteorites."

2nd. A mistake for ball lightning; the popular opinion being that a thunderbolt is a red hot stone, capable of setting fire to houses or barns, instead of a simple discharge of electric fluid. For this reason any instance of a meteorite alleged to have fallen during a thunderstorm, should perhaps be looked upon with an extra amount of suspicion.

3rd. The historical and typographical errors, common to all writers and printers.

4th. Hoaxes. These, I regret to say, have been perpetrated on two or three occasions recently, and the knowledge of the extreme importance and interest attached to the descent of a meteorite has prompted some unscrupulous persons to send to the newspapers accounts carefully compiled, and bearing every mark of authenticity, which on enquiry have been proved to be without a vestige of foundation.

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The authorities I have had occasion to consult in the preparation of the following list have necessarily been numerous; though in the case of well established stonefalls, in which there appears no discrepancy in the various references, I have thought it necessary to insert only one or two of the most important. The catalogues of Chladni and the many continental writers have already been collated and incorporated by Mr. R. P. Greg, F.G.S., in his very extensive catalogue of meteors and fireballs, from A.D. 2 to 1860, published in the Report of the British Association for 1860.* A supplementary list containing numerous additions and corrections of errors, appeared in the Report for 1867, under the title of a catalogue of Luminous Meteors and Aërolites.† Those who have had occasion to consult these two catalogues will, I am sure, unite in bearing testimony to the great care and accuracy with which they have been compiled, and when we remember that they include observations ranging through nearly nineteen centuries, and collected from every part of the world, the laborious nature of Mr. Greg's work must be apparent. Almost all the British meteorites will be found recorded in one or other of these two catalogues; though the adoption of a tabular arrangement necessary prevented the insertion of more details than a statement of the date of the event and place of occurrence, with the size and direction of the meteor when known. The column for remarks distinguishes the entries as meteors, stone-falls, iron-falls, bolides, fire-balls, &c.

A list of 20 British meteoric stones was published in 1858, in Greg and Lettsom's "Manual of the Mineralogy of Great Britain and Ireland."‡ Also a summary by myself in the *Popular Science Review*, 1866, vol. V, pp. 414, 415. Neither of these, however, contained any details beyond a simple record of the date and place of the fall.

To the Reports of the British Association I am further indebted for many notes and references included in the "Annual Observations on Luminous Meteors," commenced by the Rev. Professor Baden Powell, in 1848, and continued since his death in 1860 by a committee. In many cases I have been unable to verify, as I should have wished, some of the earlier references contained in such works as Poggendorff; Annales de Chemie, &c., but wherever necessity has obliged me to quote them second-hand, I have appended my authority for so doing.

In each of the several instances comprised in the following pages, the meteoric stone has been described in some published account to have been actually found; and the first question will be, whether this fact can be clearly proved in every case by sufficient evidence. I have omitted all

* Op. cit. pp. 48 to 118.

† id. pp. 414 to 430.

‡ Art. Iron." p. 246.

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mention of the very large number of meteors recorded in the lists of the British Association, as having been seen apparently within a short distance of the earth, and which have been known to burst over some part of Great Britain. Though there can be but little doubt that from many of these stones must have fallen, they have not been found; and, considering what thinly inhabited districts may be met with between the Land's End and Johnny Groat's house, their non-discovery cannot be a matter of surprise. Those which belonged to the class of the aërosiderites or iron meteorites may perhaps be dug up by chance at some future period, and their identity recognized; but those included under the ordinary designation of meteoric stones, and whose chemical composition consists chiefly of silicates, unfortunately bear too great a resemblance to terrestial products to admit of their origin being even suspected by those who may find them.

In closing these prefatory remarks, I should add that the following notes must not be regarded in any way as a complete synopsis, but I hope they will be the means of eliciting from some kind helpers many a fact and many a reference which has escaped my notice, and which I shall be most thankful to receive and incorporate in a supplement, together with any corrections. It would also materially increase the value of the list to ascertain the present location of each stone, and to state in what Museums specimens may be seen.

ENGLAND.

1360.—*Yorkshire.*—

"Stonefall." The earliest recorded British meteorite is thus briefly noticed in Rep. Brit. Assoc., 1860, p. 52. It would be interesting to obtain a few particulars and references to authorities.

1622.—January 10.—*Cornwall.*

"Stonefall, at Tregony. N.B.—not Devonshire." Rep. Brit. Assoc., 1860, p. 53. This entry will be noticed in a subsequent page, under the date 1723.

1623.—January 10.—*Stretchleigh, near Ermington, Devon.*

The fall of this meteorite is described by several of the old county Historians. Risdon, who was engaged between the years 1605 and 1630 in collecting materials for his Chorographical Survey of Devon, gives the following account:—Stretchleigh.—"In this siginory, A.D. 1623, there fell from above a stone of twenty-three pounds weight, which in falling, made a fearful noise, first like the rumbling of a piece of ordnance, which, in descending lower, lessened, and ended, when upon the ground, no louder than the report of a petronel. It was composed of matter like a stone singed or half burnt for lime*"

* Op. cit., p. 186.

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Westcote, writing about the same period, related the occurrence in almost the same words. "In some part of this manor (Strechley) there fell from above, 1625*—I cannot say from heaven—a stone of twenty-three pounds weight, with a great and fearful noise in falling, first it was heard like unto thunder, or rather to be thought the report of some great ordnance, cannon, or culverin; and as it descended so did the noise lessen, at last, when it came to the earth, to the height of the report of a peternel, or pistol. It was for matter like unto a stone singed, or half burnt for lime; but being larger described by a richer wit, I will forbear to enlarge on it."†

The "richer wit" here alluded to was, in all probability, the author of a pamphlet published at the time, which further describes this aërolite as having fallen on January 10th, 1623, in an orchard, near some men who were planting trees. It was buried in the ground three feet deep, and its dimensions were three feet and a half in length, two feet and a half in breadth, and one foot and a half in thickness. The pamphlet states that pieces broken from off it were in the possession of many of the neighbouring gentry. Lysons‡ adds that this pamphlet (which I have unfortunately never been able to obtain) also describes three suns seen at Tregony, in Cornwall, in 1622, and this circumstance is important, as throwing some light upon two doubtful entries referred to under the dates 1622 and 1723. In 1869 I called especial attention to the Ermington meteorite in the Transactions of the Devonshire Association§ in the hope of obtaining some clue as to the subsequent history of any of these portions, but so far, my enquiries have been unsuccessful. From the description it is highly improbable that it could have been an iron meteorite, and from comparing the weight with the size it would appear that either the latter must have been very much exaggerated by the writer of the pamphlet, or that Risdon and Westcote must have been mistaken in the weight.

1628.—April 9.—*Hatford, &c., Berkshire.*‖

This fall took place about 5 or 6 o'clock in the afternoon, and by a comparison of various accounts, seems to have spread over a large area. Mr. T. W. Webb¶ directs attention to a letter preserved in Wallington's *Historical Notices*, i, 13, which was written in 1628, by Mr. John

* A probable misprint for 1623.

† A view of Devonshire in 1630, by Thomas Westcote, gent., Oliver's Ed. Exeter, 1845, pp. 391, 392.

‡ Lysons' Magna Britannia. vol. vi, pt. 2; Devon, pp. 175, 176.

§ Op. cit., vol. III, pp. 75, 78.

‖ Erroneously described in Greg and Lettsom's Mineralogy, p. 246, as August 9 Hatfield.

¶ Nature, July 14, 1870.

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Hoskins, dwelling at Wantage, to his son-in-law Mr. Dawson, a gunsmith, dwelling in the Minories without Aldgate, relating to the fall of these meteorites. Describing the explosion, Hoskins says:—"It began as followeth: First, as it were, one piece of ordnance went off alone. Then, after that, a little distance, two more, and then they went as thick as ever I heard a volley of shot in all my life; and after that, as it were the sound of a drum . . . . . .Yet this was not all; but as it is reported, there fell divers stones, but two is certain in our knowledge. The one fell at Chalows, half-a-mile off (from Wantage), and the other at Barking five miles off. Your mother was at the place where one of them fell knee-deep, till it came to the very rock, and when it came at the hard rock it broke, and being weighed, all the pieces together, they weighed six and twenty pound. The other that was taken up at the other place weighed half a tod, 14 pound."*

The weight of the stone which fell at Hatford was 24 lbs. according to the entry in the Rep. Brit. Assoc., 1860, p. 54. These three points Hatford, Challow, and Barking (Balking or Baulking?) give some idea of the size of the space over which the meteoric fragments were dispersed. As measured on the map, it forms a triangle, Balking and Hatford being the base, about three miles in length; and each point being distant from Challow about four miles.

1642.—August 4.—*Near Woodbridge, Suffolk.*

This stone fell at 4.30 in the afternoon, and weighed 4 lbs. Noticed in Gentleman's Magazine, 1796, p. 1007; Rep. Brit. Assoc., 1860, p. 54.

1680.—May 18.—*London.*

Several meteoric stones are said to have fallen on this occasion; some being near Gresham College—Rep. Brit. Assoc., 1860, p. 55. The fall is noticed by Chladni, Annales de Chimie, 1826, p. 257 (Phipson).

1723.—*Cornwall, England.*

"Stonefall (not in 1622 as in Cat. No. 1)" Rep. Brit. Assoc., 1867, p. 414. This entry has caused me much perplexity, and I believe it to be only the result of an involved series of mistakes. The original entry in the first catalogue, of which this is a correction, gives as already mentioned under date 1622, January 10. "Cornwall, England.—Stonefall at Tregony. N.B.—Not Devonshire." It is a curious circumstance that in the corrected entry the year only is given, the month and day being omitted. Also that the next succeeding entry relating to a meteorite at Halstead, Essex, in 1731, is dated Jan. 10, instead of March 12, which according to all other authorities was the true date of this descent.

* W. Flight, Geol. Mag., Ser. 2, Vol. II. p. 266.

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I cannot but think, in spite of the fact that Ermington in Devon and Tregony in Cornwall are some 42 miles apart, the whole of the entries refer to the same event. The Ermington or rather Strechley meteorite, so well established by the evidence of several contemporaneous writers, is omitted in both the Brit. Assoc. Catalogues, and the date Jan. 10, 1623, has been altered by Chladni, and in Greg and Lettsom's Mineralogy, to Jan. 10, 1622. This, however, is easily explained, as at that time the civil year terminated on March 25th, and an occurrence taking place in January would be indifferently entered as belonging either to 1622 or 1623.

If the entry in the second catalogue be correct, the coincidence of two stone-falls in adjoining counties, with the exact interval of one hundred years between them would be a very remarkable one; but I believe the most probable explanation is, that the meteor which fell at Strechley, on Jan. 10, 1622 or 3, came in a westerly direction at a somewhat low angle, and was seen to pass over Tregony, though by some slight error in the date, the two occurrences, which in fact were separated from each other only by distance, have also become separated by a greater or less interval of time.

1725.—July 3.—*Mixbury, Oxfordshire.*

Stonefall; weight 20 lbs. Rep. Brit. Assoc., 1860, p. 56. Greg and Lettsom's Manual of the Mineralogy of Great Britain and Ireland places the occurrence under the same date, at Mixburg, Northamptonshire: but this is clearly a mistake.

1731.—March 12.—*Halstead, Essex.*

"Stonefall and fireball." Rep. Brit. Assoc., 1860, p. 56. In the supplementary catalogue the entry stands thus:—"1731, Jan. 10, Halstead, Essex; detonating meteor; Stonefall doubtful, Cat. No. 1." As stated in the preceding page, I am inclined to think that the date Jan. 10 has been printed in error, and belongs to another event.

1780.—April 1.—*Beeston, Northamptonshire.*

Stonefall at 9 p.m., April 11? Ironfall? Rep. Brit. Assoc., 1860, p. 60.

1795.—December 13.—*Wold Cottage, Thwing, East Riding of Yorkshire.*

This celebrated meteorite fell on a Sunday, at 3 o'clock in the afternoon, in the grounds of Major Topham. It penetrated into nineteen inches of soil and hard chalk, and weighed 56 lbs. The stone was transferred by Major Topham to Mr. Sowerby, and was subsequently purchased by the British Museum for £250.* According to the official catalogue the present weight is 47 lbs. 9 ozs. 53 grains.† The Imperial cabinet at

* Sowerby's Mineralogy, p. 222.

† The latest catalogue gives the weight as 45 lbs. 8 ozs.

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Vienna also possesses a small specimen. The specific gravity as given in Rep. Brit. Assoc., 1860, p. 61, is 3·70. In 1796 the stone was exhibited in London, and in the same year an account of the fall was published in the Gentleman's Magazine. The chemical composition was investigated by Luke Howard, and compared with that of Meteorites from Portugal, Sienna, and Benares. The results were published in the Philosophical Transactions for 1802, under the title of "Experiments and Observations on certain Stony Substances, which at different times, are said to have fallen on the Earth." According to Phipson* this paper is remarkable as containing the first chemical analysis of an aërolite that was ever made.

1803.—July 4.—*East Norton, near Leicester.*

"Stonefall? meteor and detonation; struck a building; electrical?" Rep. Brit. Assoc., 1860, p. 62. A note refers to an account in the Encylopædia Britannica. It is described as being more like an electric ball, and yet a vitrified stone was found, containing nickeliferous iron. This should, perhaps, be included amongst the doubtful instances.

1806.—May 17.—*Basingstoke, Hampshire.*

"Stonefall after a detonating meteor," weight 2½ lbs. Rep. Brit. Assoc., 1860, p. 63.

1813.—August or September.—*Malpas, Cheshire.*

Dr. T. Thomson, in his *Annals of Philosophy* for November, 1813,† states that he received some weeks previously a letter from Chester, dated the 15th of September, containing the following information, which the writer says was first communicated to the public in a provincial newspaper. He does not give the date; but merely quotes the following passage from the newspaper, in the words of the anonymous writer of that article.—"Last week having occasion to go to Malpas (a village 15 miles from Chester), I witnessed a very singular phenomenon. About one o'clock in the day, from the great heat and calmness of the air, I apprehended a thunder storm, and supposed my apprehensions were going to be realized, when I beheld a bright cloud, out of which fell some large stones, which were soft and intensely hot at first, but afterwards acquired considerable hardness." Dr. Thomson adds:—"I am not aware that any of the stones in question have been brought to London. These phenomena have been of rare occurrence in Great Britain of late; but five or six examples of similar falls on the continent, during the years 1811 and 1812 have been recorded, and the stones subjected to chemical analysis."

1816.—August or July.—*Glastonbury, Somerset.*

"Stonefall." Rep. Brit. Assoc., 1860, p. 65.

* Meteors, aerolites, and falling stars, p. 5.

† Vol. II, pp. 396, 397.

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1825 ?—May 12.—*Bayden, Wiltshire.**

"Ironfall" (Poggendorff, VIII, 1826.) "According to P. A. Kesselmeyer, of Frankfort, the piece of iron which fell is in possession of Mr. Schwickard, in Mexico, who bought it from a mineral dealer in London. Prof. Nöggerath, of Bonn, is said to have seen it; it looked like meteoric iron, and the magnetic needle was greatly affected by it. Possibly the same as the large meteor seen in Gloucestershire, May 12, 1826," and which according to Baumhauer was aërolitic, and visible in Wiltshire. Rep. Brit. Assoc., 1860, p. 71.

1827 or 1828 ?—August or September.—*Allport, Derbyshire.*

At 3 p.m. a meteoric light traversed the sky, followed by an explosion. "The meteorite picked up, supposed to have fallen on this occasion, now in Dr. R. A. Smith's possession, of Manchester, appears to Mr. Greg to be a more than doubtful substance; more like a kind of compact charcoal, with particles of sulphur and iron pyrites imbedded; nevertheless peculiar; pieces are stated to have fallen after the explosion occurred." Specific gravity 2·0. Rep. Brit. Assoc., 1860, p. 72.

1830.—Februry 15.—*Launton, near Bicester, Oxfordshire.*

A stone weighing 2½ lbs. fell at 7 p.m. with noise and light. Specific gravity 3·625. Rep. Brit. Assoc., 1860, p. 72, According to the same authority, it was in the possession of Dr. Lee, F.R.A.S. See Buck's Gazette, April 10, 1830.†

1835.—August 4.—*Aldsworth, near Cirencester, Gloucestershire.*

This meteorite fell at 4.15 p.m., and originally weighed 2 lbs. Specific gravity 3·4. The weight of the portion in the British Museum is given in the catalogue as 1lb. 2ozs. 128g. According to Rep. Brit. Assoc., 1860, p. 75, a great concussion high up in the air was heard at the same time in South Herefordshire, and probably resulted from the bursting of this meteor.

1842 ?—August 5.—*Harrowgate, Yorkshire.*

5 p.m., Stonefall (Kämtz). "A hot stone like basalt, accompanied by whistling in the air, and lightning and thunder, said to have fallen; resembling a stone that fell some years before at Cardiff, further particulars of which latter not obtainable at present (see Poggendorff, Supp. IV, 1854, p. 366; also, l'Institut, No. 457.) The Harrowgate stone is described also as containing silver-white metallic looking particles. N.B.—A very doubtful fall." Rep. Brit. Assoc., 1860, p. 80.

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* Baydon, near Hungerford ?

† I believe this meteorite was in the Oxford University Museum, in 1863, but my note with reference to it is unfortunately mislaid.

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1876.—April 20.—*Rowton, Wellington, Shropshire.*

With the exception of the somewhat doubtful iron meteorite already noticed in 1825, at Baydon, Wilts, this is probably the only recorded instance of the fall of an aërosiderite in the British Isles. An account published in the *Times* of April 26, 1876, gives as the exact locality, a turf field near the Wellington and Market Drayton Railway, about a mile north of the Gradgington Station. It is stated that about ten minutes to 4 on Thursday afternoon, within a seven mile's radius of the Wrekin, the villages were alarmed by an unusual rumbling noise in the atmosphere, followed immediately by an explosion, resembling the discharge of heavy artillery. Rain was falling heavily throughout the afternoon, but there was neither lightning or thunder. About an hour after the report, a Mr. G. Brooks went into a meadow in the occupation of his stepfather, Mr. Bailey, and noticed that a hole had been cut in the ground. He probed it and found that what was apparently a hard stone had buried itself in the ground to a depth of 18 inches, passing through four inches of soil and 14 of clay. It rested on the gravel beneath these, and was quite hot, although nearly an hour had elapsed from the time of the explosion being heard. The stone was dug up and removed to Wolverhampton, where it was found to be a mass of meteoric iron. The hole was almost perpendicular, and the meteorite is assumed to have fallen in a south-easterly direction.

The meteorite was in the possession of Mr. Gibbons of Wolverhampton, and was first exhibited at a Bazaar in aid of St. Peter's Church, and afterwards at a Meeting of the Birmingham Natural History Society. Subsequently, with the consent of the Duke of Cleveland, in whose property it fell, it was presented to the British Museum. The Report of the British Association Committee on 'Luminous Meteors' (1876, p. 166), gives some additional particulars from a communication by Professor Maskelyne* It is described as weighing 7¾ lbs.† and being a mass of "metallic iron irregularly angular, although all its edges appear to have been rounded by fusion in its transit through the air, and, except at the point where it first struck the ground, it is covered by a thin black pellicle of the magnetic oxide of iron. The surface is somewhat pitted or marked with slight depressions, one of which occurring in a fissure of the mass, affords some instructive evidence of the causes of their formation. The exposed metallic part of the surface exhibits crystalline structure very clearly when it is etched.....It is only the seventh aërosiderite or meteoric iron of which the fall has been witnessed, although upwards of a hundred iron

* "Nature," July 27, 1876, vol. XIV, p. 472.

† The exact weight of the specimen in the British Museum, as given in the last catalogue, is 7 lbs. 11 ozs.

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masses have been discovered in different parts of the globe, which are undoubtedly meteoric, and two such have been found in Great Britain.*"

ISLE OF MAN.

1813 to 1819.—*Pulrose.*

"Stonefall; light and scoriaceous." Rep. Brit. Assoc., 1860, p. 67.

SCOTLAND.

1676.—*Orkneys.*

"Stonefall; fell into a boat." Rep. Brit. Assoc., 1860, p. 55.

1802 ?—September 15.—*Loch Tay.*

"Stonefall; doubtful." See Monthly Magazine, October, 1802, p. 290. Rep. Brit. Assoc., 1860, p. 62. In Greg and Lettsom's Mineralogy a meteorite is stated to have fallen in Scotland, in October, 1802. This probably refers to the same occurrence: the date of publication being mistaken for that of the actual fall.

1804.—April 5.—*High Possil, Glasgow.*

According to Phipson† this stone fell with a loud hissing noise, preceded by explosions. The Rep. Brit. Assoc., 1860, p. 62, adds that it took place in the day time, and gives the specific gravity of the stone as 3·53, a portion weighing 3 oz. 95 grains is in the British Museum, and another in the Imperial Cabinet at Vienna.

1830.—May 17.—*Perth.*

Catalogue British Museum; the weight of the specimen is under 1 oz.

Of meteoric iron not seen to fall, two instances have been discovered in Scotland, the first is described by Greg and Lettsom‡ as being "a small angular and rounded mass, with a closely crystalline texture, is extremely hard, and where cut and polished, shows numerous small triangular figures, more brilliant than the rest of the surface, as in most meteoric irons. It was found a good many years back by Da Costa at Leadhills, and is now in Mr. Greg's collection." A small fragment under 1 oz. in weight is in the British Museum, the catalogue of which fixes the date of discovery between the years 1820 and 1830.

The other example was found at Newstead in Roxburgshire, and is dated 1861 in the same catalogue, the weight being 18 lbs. 1 oz.‖

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* Leadhills, and Newstead in Scotland.

† Meteors, Aërolites, and Falling Stars, p. 40.

‡ Manual of the Mineralogy of Great Britain and Ireland, 1858, p. 245.

‖ The latest Catalogue gives the date 1827.

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IRELAND.

1771 ?—Locality ?

Stones said to have fallen. Rep. Brit. Assoc., 1860, p. 59. A stone like a grey siliceous pebble. Annales de Chemie, vol. lxxxv, p. 278, 1813. Possibly same as 1779 at Pettiswood.

1779.—*Pettiswood, County Westmeath.*

Weight 5 oz. Gentleman's Magazine, Sept. 1796. Rep. Brit. Assoc., 1860, p. 60.

1810.—August.—*Mooresfort, County Tipperary.*

According to the entry in Rep. Brit. Assoc., 1860, p. 64, this meteorite fell at 11.30 a.m. on August 10. Specific gravity, 3·67. Two portions are preserved in the Museum of the Royal Dublin Society, and are thus described in the catalogue :—"Meteorolithe of an ash-grey colour, coarse grains, with imbedded particles of malleable iron, iron pyrites, minute globules of a soft greyish-brown substance, and grey mica. It fell near Mooresfort, County Tipperary, in the month of August, 1810. It weighed seven pounds and three quarters, and was of a somewhat cubical shape."

Five specimens in the British Museum weigh 12 ozs., one of which was described in an old catalogue as containing quartz globules of a greenish colour, owing to oxide of nickel. The Imperial Cabinet of minerals at Vienna also possesses two specimens.

1813.—September 10.—*Adare, &c., County Limerick.*

This is a very important stonefall, as it consisted like that in Berkshire in 1628, of many distinct portions spread over a large area. In the Rep. Brit. Assoc., 1860, p. 65., the weights of three are stated at 15 lbs., 65 lbs., and 24 lbs., with a specific gravity of 3·64. According to the same authority the fall took place at 9 o'clock in the morning.

The following localities are given :—

Limerick, neighbourhood of (Cat. Roy. Dub. Soc.)
Patrick's Well, Limerick (Cat. Mus. Trin. Coll. Dub.)
Adare (Cat. Trin. Coll. Dublin : Brit. Mus., Vienna, &c.)
Faha (Cat. Brit. Mus.)
Scagh (Rep. Brit. Assoc., 1860, p. 65.)
Brasky (Phillips's Mineralogy by Brooke and Miller.)

The mineralogical description of three specimens in the Museum, Trinity College, Dublin, is thus given in the catalogue. (1) "Exterior coating of a dark brown colour, and exhibiting the appearance of semi-fusion. Fracture surface granular, gray, and presenting a few metallic points of a light colour and metallic lustre. Adare.—(2) "Ash-gray

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colour, and coarse granular fracture, with some yellowish-brown spots and numerous imbedded particles of meteoric iron; external crust brown and glazed. Limerick.—(3) Fracture surface of a granular structure and gray colour, with yellowish spots and numerous shining imbedded particles of meteoric iron. Patrick's Well."

The Royal Dublin Society's collection possesses two "meteorolithes of a bluish-grey colour; with metallic grains, partly covered with a brownish-black glazed crust, which fell with others in the neighbourhood of Limerick." These no doubt belong to the same descent. The Imperial Cabinet at Vienna has three specimens from Adare. The British Museum specimen weighs 3 ozs. 105 grains.

The chemical constituents of this meteorite, originally investigated by Professor J. Apjohn* has recently been examined by R. Apjohn,† who finds that it contains a trace of Vanadium; but the date which he assigns to the fall of this stone (1810) appears to be that of another Irish meteorite which fell at Mooresfort, Tipperary. The nickel-iron has the composition:—Iron, 85·120; Nickel, 14·275; Cobalt, 0·602; Phosphorus, trace=99·997; and the result of the treatment with acid:—

	SiO_2	Al_2O_3	FeO	MnO	CaO	MgO	Na_2O	K_2O	P_2O_5	
Soluble	42·91	2·35	16·93	6·26	5·34	24·32	0·29	0.02	—	=98·42
Insoluble	59·48	3·24	7·94	8·84	4·62	13·17	1·86	0·30	trace	=99·45

The mineralogical composition of the stone is stated to be—

Nickel-iron	19·07
Chromite	1·75
Magnetic-pyrites	6·54
Soluble Silicate	35·44
Insoluble Silicate	37·07
	99·87

1844.—April 29.—*Killeter, near Castle Derg, County Tyrone.*

This fall is entered in the Rep. Brit. Assoc., 1860, p. 82, as occurring at 3·30 p.m., and is thus described:—"specific gravity 3·76. Stonefall. No meteor; many small ones; musical sounds in the air." I have obtained no further information than this. A specimen in the British Museum weighs under 1 oz.

1860?—June 8 or 9.—*Raphoe, County Donegal.*

Stonefall at 2 p.m., during a storm of thunder and hail. Rep. Brit. Assoc., 1860, p. 107, refers to the *Londonderry Sentinel* of June 15, 1860: "It does not appear there was any fire-ball; the stone resembled friable

* J. Apjohn, Trans. Royal Irish Acad., xviii, 17.

† R. Apjohn, Journ., Chem. Soc., Ser., 2, vol. XII, p. 104 (see Rep. Brit. Assoc., 187 p. 246, and Geol. Mag. Ser. 2, vol. II, p. 367).

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sandstone; it was seen to fall near Raphoe, and was about as large as a duck's egg. It had neither outside crust, nor shining metallic particles; was quite cold and moist when picked up. The fragments of this stone have been mislaid or lost, unfortunately."

1865.—August 12.—*Dundrum, County Tipperary.*

Meteor not seen. At 7 p.m., a report like a cannon-shot and buzzing noise was heard, and the stone fell into the ground, where it lay, half-buried in the earth, milk-warm; weight 4 lbs. 14 ozs.; specific gravity 3·07 to 3·57 in different parts of the stone, which has the form of a three-sided pyramid; the base freshly broken; the faces vitrified and separated from each other by sharp edges of the crust, as distinctly as if ruled with a ruler. Of the earthy portion of the meteorite, that which is soluble in muriatic acid is nearly pure olivine; the insoluble portion is a highly siliceous mineral.

The proportions are:—

Nickel-iron (Chladnite) ..	20·60 (Fe 19·57; Ni 1·03)
Protosulphuret of Iron (Troilite)	4·05
Chrome Iron-ore	1·50
Mineral soluble in Muriatic Acid	33·08 (FeO 5·89; MgO 14·81)
Mineral insoluble in do.	40·77
	100·00*

A fragment in the British Museum weighs under 1 oz.

APPENDIX.

DOUBTFUL OR FICTITIOUS STONE-FALLS.

1594.—*Leominster, Herefordshire.*

Among the municipal records of the town of Ludlow is preserved a vellum roll, with a list of Bailiffs in the time of Queen Elizabeth. Under the above date occurs the following entry:—

"A greate barne in Lempster fired by a commett, and burned 15 dayes." (Rep. Brit. Assoc., 1865, p. 128.)

1640.—Whit-Sunday.—*Antony, near Plymouth.*

A tract by the Rev. Arthur Bache bears the following title:—"The Voyce of the Lord in the Temple; or a most strange and wonderfull Relation of God's great Power, Providence, and Mercy, in sending very strange sounds, fires, and a Fiery Ball into the Church of Anthony neere Plimmouth, in Cornwall, on Whit-Sunday last 1640. To the scorching

* Rep. Brit. Assoc., 1866, p. 131. (From Scientific Papers Royal Irish Academy Proc., vol. I, p. 230.)

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and astonishment of fourteen severall persons who were smitten, and likelikewise to the great Terrour of all the other people then present, being about 200." (Bibliotheca Cornubiensis.)

1668 (about).—*Wethersfield, Essex.*

In a letter dated 14th Feb., 1868, the late Rev. R. Kirwan, F.S.A., informed me "that in the old registers of the Parish of Wethersfield there is a notice in Latin of two meteorites that appeared about 200 years ago."

1791—October 20.—*Menabilly, near Fowey, Cornwall.*

Included in the list of Meteoric Stones by Chladni, and in Greg and Lettsom's Mineralogy. The Rep. Brit. Assoc., 1860, describes it as a fall of hail-stones.

1844 or 1845.—*Lymington, Hampshire.*

A supposed aërolite said to have fallen.

1846.—August 10.—*County Down, Ireland.*

"An iron said to have fallen and been picked up, but either the whole story is a hoax, or the iron itself purely artificial." (Rep. Brit. Assoc., 1860, pp. 84, 85.)

1852.—December 17.—*Dover, Kent.*

A meteor probably aërolitic, appeared to fall partly in the sea, about half a mile from land, and partly on the beach. The stones said to have been found after the explosion, proved to be nodular concretions of pyrite, identical in all respects with those so common in the neighbouring cliffs. (See also Phipson's Meteors, pp. 54, 55).

1858.—May 4.—*Aylesbury, Buckinghamshire.*

An ignited globe, exploding with noise, set fire to a straw-yard. "Hit a cow; smell of sulphur; no stone found; probably electrical." Rep. Brit. Assoc., 1860, p. 95.

1858.—June 12.—*Birmingham.*

See subsequent notice, 1868, May 29.

1860.—July 29.—*Little Bridy, Dorsetshire.*

"? A dark substance fell with noise and light on reaching ground." Rep. Brit. Assoc., 1867, p. 418.

1861.—August 1.—*Chorley, near Lancaster.*

A letter in the *Times* with the above date and address, gave a most circumstantial account of the fall of an aërolite 83½ lbs. in weight. It was described as an irregular ellipse, the major axis being 11¾ inches; the minor axis 7⅝ inches. It fell into a road, and buried itself nearly 6 feet in the ground. I made several inquiries at the time, but failed in ascertaining that there was any truth in the narrative.

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1868.—May 29.—*Birmingham.*

The *Birmingham Daily Post* for May 30, 1868, contains a letter signed Thomas L. Plant, F.M.S., describing a violent thunderstorm on the previous morning. The concluding paragraph of the letter is as follows:—"There was an extraordinary phenomenon during the deluge of rain. From nine to ten, meteoric stones fell in immense quantities in various parts of the town. The size of these stones varied from about $\frac{1}{8}$th of an inch to $\frac{3}{8}$ths of an inch in length, and about half those dimensions in thickness. They resembled in shape broken pieces of Rowley ragstone. A similar phenomenon visited Birmingham ten years ago. On the 12th of June, 1858, during a severe thunderstorm, there fell a great quantity of meteoric stones, in every respect like those discharged this morning."

As another alleged meteoric storm took place in the same neighbourhood, and at an interval of less than a year, it may be interesting to compare the two accounts.

1869.—May 25.—*Wolverhampton.*

The following extract from the *Birmingham Gazette* appeared as a reprint in Symons's Monthly Meteorological Magazine*—"At the conclusion of the thunderstorm at Wolverhampton, on Tuesday evening, several persons noticed a large number of small dark stones lying upon the streets and roads, the drive of the London and North Western Railway Station, Queen Street, Queen Square, and Waterloo Road being especially strewed with them. From the peculiar character of the stones, bearing resemblance to nothing with which the roads are paved, or any stones found in the district, it was concluded even by the uninitiated, that they were meteoric stones, and must have fallen during the heaviest and most alarming period of the storm. A considerable number was gathered that night, and more the next morning. Our correspondent has some in his possession, and has shewn them to several gentlemen, one of whom saw the last shower of meteoric stones that fell at Birmingham in June last, and stated that those that have fallen at Wolverhampton were precisely of the same character. They appear, however, to have been a little larger ....those at Birmingham being from $\frac{1}{8}$th to $\frac{3}{8}$ths of an inch,....while some of those picked up in Wolverhampton were $\frac{3}{4}$ of an inch in length, and $\frac{3}{8}$ths of an inch in thickness. Like the stones in Birmingham, too, they have something like the appearance of Rowley rag, but on breaking them up the difference of character is at once apparent. A chemist in the town found that, by judging from mere surface examination, they resembled iron pyrites. The matter is exciting a very general attention,

* Op. cit., vol. IV, pp. 137, 138.

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and there are a great many searchers gathering up the remains of this strange shower from the heavens."

Immediately on seeing in the newspapers the account of the supposed fall at Birmingham, I made numerous inquiries by letter, and endeavoured, but without success, to obtain a single fragment of the stone said to have fallen in such quantities. An editorial note appended to the extract in the Meteorological Magazine invited further particulars regarding the Wolverhampton shower, but was only met by a letter containing a general denial of the truth of the statements. Taking the whole of the evidence, I think it must be conceded that in both cases fragments of stone did actually fall during the thunderstorms; but the meteoric origin of the fragments by no means follows as a matter of course. Instances of dust and small stones being taken up from the ground, and carried along for a considerable distance by a storm, are not unknown, if uncommon, and in the absence of any analysis or other reliable data, it may be suggested that the showers at Birmingham and Wolverhampton were due to this cause.

1869.—November 6.—*Fawley, near Southampton.*

The *Standard* described two meteors seen about 7 p m., and a "meteorite" weighing more than 1 lb., which was discovered four days later. "It had not penetrated the ground more than half an inch." From the account it would appear to have been a nodule of iron pyrites, washed out of the soil by heavy rain. (See W. Flight, Geol. Mag., Ser. 2, vol. II, p. 26.

1874.—August 1.—*Hexham, Northumberland.*

In the *English Mechanic* for Aug. 21st, a letter signed "Ralph Lowdon," of Gateshead, describes a massive ball of intense light accompanied by other pear-shaped balls of fire, seen to drop towards the earth.

The aërolite which is alleged to have fallen in an orchard on the bank of the North Tyne, at no great distance from Hexham is stated to have been found the following day at 9 a.m., at a depth of 14 inches in the soil, still quite warm, and to have weighed 301½ lbs. Enquiries made by Dr. W. Flight, F.G.S., resulted in the return of his letters by the Post-Office authorities, and a reply from the Rector of Hexham that he cannot find even the slighest foundation for the statements.*

* Rep. Brit. Assoc., 1875, p. 240; and Geol. Mag., Ser. 2, vol. ii, p. 263.

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II.—*The Geognosy and Mineralogy of Scotland.*—By Professor Heddle.

MAINLAND, Part II.

HILLSWICK NESS.

THIS is a mere fragment of gneissic rocks which is imbedded between the granite of Roeness and the igneous rock which lies to the east: but so different are these entrapped rocks from the ordinary gneiss of Shetland, and so violent a twist do they seem to have received athwart of their normal strike, that the enquiry rises—whence did this fragment come?

A spectator looking west from the top of Ornsfield, gazes seaward upon a mere heap of ruins; while, looking landward, he also sees little else,—so riven and twisted are the rocks by the intrusion of dykes of porphyry, and so shattered and toppling from the invasion of the sea.

The strata lying to the north of this rising ground may be included under the name of hornblendic gneiss, though in many places they more resemble diorite; those lying southward of a line drawn south-eastward from this spot, are chiefly of the nature of chlorite slate.

Every variety of such rocks and endless intermediates, however, occur; they are so convoluted and crushed into one another that dips of all angles, and strikes which appear to radiate from a plurality of centres are not unfrequent.

However distracting to the geologist, such a land of promise to the mineralogist and lithologist is but rarely to be seen.

Despite of the rock turmoil within, or perchance as a result thereof, the ground is so uniformly covered with a firm and close sward, that it is only on the coast line that exploitation can be carried out; and so break-neck is much of the shore that the following record cannot but be incomplete.

At the *Ting of Turness*, *hornstone* of a brownish-red colour occurs (Hb), it is somewhat earthy, and occasionally porphyritic, the imbedded crystals being bright-red twinned orthoclase. There is here much "claystone porphyry."

At *Staba*, on the north, and at an equal distance from the mouth of the *Nidister* to the south, *hornblende* occurs imbedded in white *albite*

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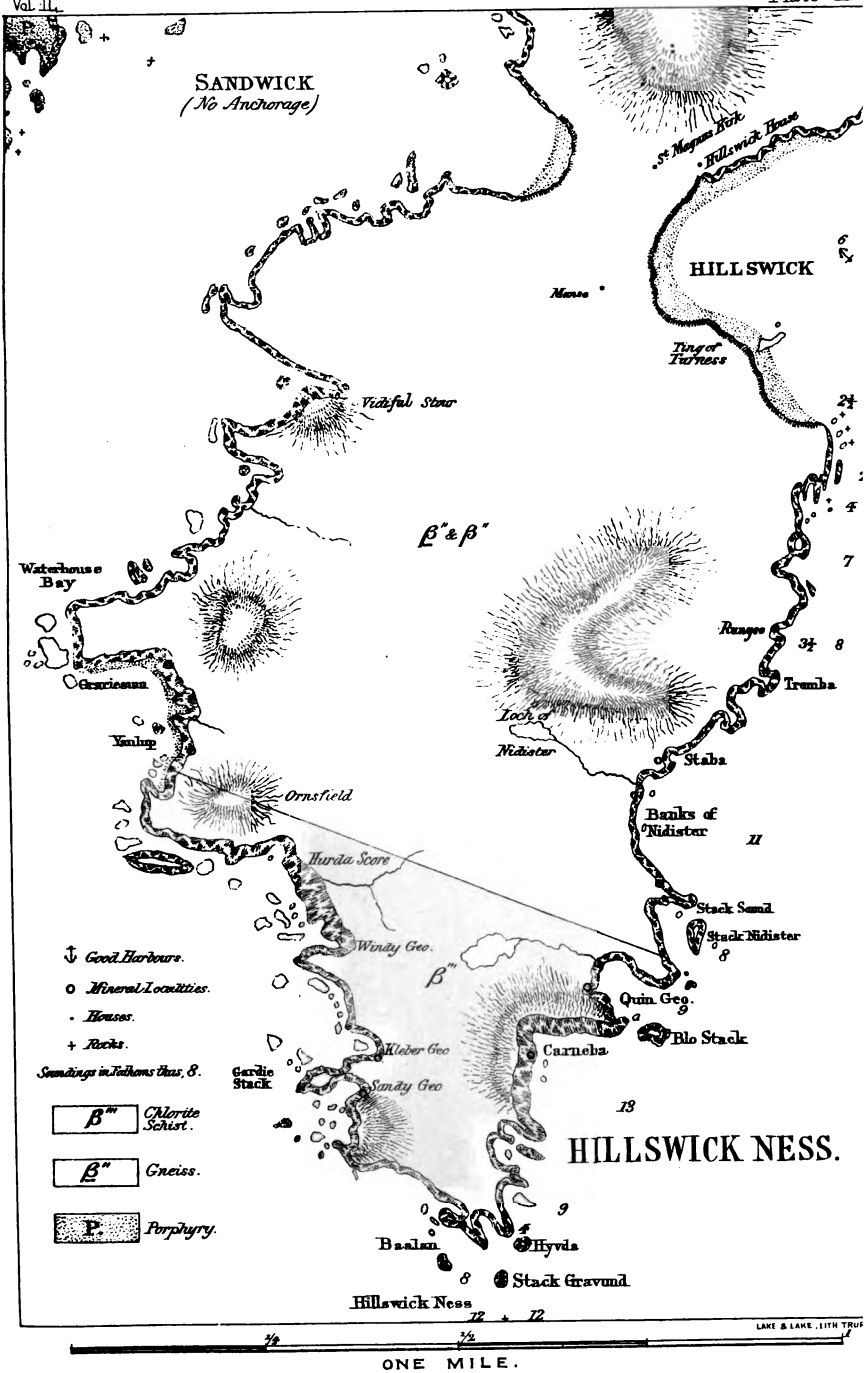

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(D. & H.) The former is here of two very different appearances,—in the first, plumes or divergent brushes, a couple of inches in length, of lustrous dark-green crystals, lie bedded in snow-white cleavable masses of albite; in the second, flat, equally lustrous, foliated crystals are impacted singly in the same matrix. Both are striking varieties.

The latter of these spots affords specimens in which pink or flesh coloured *albite* is in foliated crystals, imbedded in the white variety. The specific gravity of this pink variety is 2·615. Its unusual colour induced me to analyse it.

It yielded—

Silica	66·711
Alumina	19·813
Ferrous Oxide	·9
Magnesia	·093
Lime	1·382
Potash	1·264
Soda	9·229
Water	·542
	99·934 (H.)

This albite was minutely striated.

The compound of albite and hornblende is in such quantity as to constitute a rock.

The diorite of Fetlar contains hornblende and *anorthite;* that of Colafirth and Nidister, hornblende and *albite.*

The low rocks and shore south of the mouth of the Nidister ("*the Banks of Nithista*") afford several varieties of *hornblende*, and in large quantities (Hb.); a variety in jet black highly lustrous minute scales, and another in large interlacing crystals of considerable lustre and a dark green colour, are perhaps the finest.

This hornblende sometimes contains cavities filled up by radiating crystals of *epidote* (D. & H.) of the thickness of knitting needles, and an inch or more in length. This epidote was dull, soft looking, and of an olive green colour; its only associates were a fiery-red granular felspar, and a bright red substance which occurred in thin investing layers, and which (or something very similar to which) I have also seen in granite in Rubislaw, as well as elsewhere, with hornblende.* The specific gravity of this epidote was 3·396.

* I believe this to be an undescribed mineral, but I have never been able to get enough for analysis.

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It yielded,

Silica	37·866
Alumina	24·722
Ferric Oxide	9·961
Ferrous Oxide	·361
Manganous Oxide	·536
Lime	23·104
Magnesia	·766
Water	2·822
	100·078 (H.)

Although the inclosing hornblende has no appearance of even incipient decomposition, yet it must be said that the epidote has itself some appearance thereof.

The same spot also yields veins (?) consisting of transverse fibres of leek-green *actynolite*, with occasional plates of brilliant *Biotite*. (D and H.)

A nook, just where these banks become cliffy and curve round to the east, is quite a nest of minerals; these occur in beds which strike inland to the north-west, and eastward are seen in a little rocky stack.

First there occurs or rather occurred "a bed of *actynolite* not less than two feet in width, of a fibrous structure, of a splendid leek-green or pistachio-green colour, and of a silky lustre." (Hb.) Hibbert hardly does justice to the beauty of this bed, the few remaining bits of which the writer bore away. The mineral was in parallel crystals half an inch in width, these were separated from each other by films of a soapy *chlorite* (?); the crystals are well-formed six-sided prisms, but are not terminated; they are semi-transparent and green. Their specific gravity is 2·993.

They yielded,

Silica	55·
Alumina	1·512
Ferric Oxide	·994
Ferrous Oxide	3·456
Manganous Oxide	·307
Lime	10·381
Magnesia	23·307
Potash	1·12
Soda	1·097
Water	2·898
	100·072 (H.)

There immediately follows on the south of this wrought out bed of glassy actynolite, a bed of *precious serpentine* of the finest character. (D.

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and H.) It is in two layers—one is a rich green to sulphur yellow, the other a rich umber brown. Both are highly translucent; they are very brittle, cut with a knife like slate pencil, but still are softer than the nail. They are very uniform and pure.

The specific gravity of the green is 2·522.

It yielded,

Silica	41·46
Alumina	·01
Ferric Oxide	2·422
Ferrous Oxide	1·163
Manganous Oxide	·23
Lime	trace.
Magnesia	41·763
Water	12·43
	99·478 (H.)

In contact with this serpentine there is found a bed about two feet thick of *anthophyllite* (H.) The outside layers of this bed consist of flat short crystals of the mineral; its inner portion is an interlacing mass of crystals, which are about two inches in length. These lie in all directions, are of a clove-brown colour, and of a vitreous lustre. From the manner in which the crystals are relatively disposed, as well as from their own nature, they form a mass of the most extreme toughness.* Minute specks, which appear to be *molybdenite*, are to be seen among the crystals. (H.)

The specific gravity of this anthophyllite is 3·068; the cleavage angle of the crystals 125° 23′.

They yielded.

Silica	56·861
Alumina	4·495
Ferrous Oxide	8·131
Manganous Oxide	·871
Lime	1·087
Magnesia	25·874
Water	3·355
	100·624 (H.)

* A lump. less than a cubic foot in size. could not be broken by a 28 lb. hammer, and after repeated blows had failed in producing the smallest sign of fracture, it was found that the steel, of 1½ inch in thickness, was rent across the whole face. The baffled quarry man happily characterised the mass as a "bundle of petrified nails."

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Two veins or beds were observed in the shingle running seaward from this corner; on sufficient exposure, they were found to consist the one of *Biotite*, the other of *talc-chlorite* of Traversella. (D. and H.)

The Biotite was a mass of soft, friable, scaly crystals, hardly cohering; its colour was brown, it had little lustre, and was soapy to the touch. Its specific gravity was

It yielded,

Silica	39·803
Alumina	14·185
Ferric Oxide	2·594
Ferrous Oxide	11·784
Manganous Oxide	·24
Lime	·097
Magnesia	18·32
Potash	8·43
Soda	2·11
Fluorine	·56
Water	2·52
	100·643 (H.)

The substance which formed the second vein, which was of much larger dimensions, was examined partly on account of a peculiarity in its appearance and partly from its appearing to Professor Roscoe to be very similar to the foliated green vanadiate which had been named after himself. It occcured in such quantity that it could be raised in spadefuls: It was quite pulpy, had a higher and more pearly lustre than chlorite or clinochlores, and in certain positions reflected a light of a golden hue. Its colour was that of a somewhat pale chlorite. As it fell asunder into loose scales in water, its specific gravity could not be ascertained.

It yielded,

	Dry.	Wet.
Silica	39·81	35·461
Alumina	11·432	10·183
Ferrous Oxide	7·974	7·103
Manganous Oxide	·259	·23
Lime	2·804	2·498
Magnesia	25·648	22·846
Potash	1·203	1·072
Soda	3·152	2·808
Water	7·913	17·994
	100·195	100·195 (H.)

It lost at 212° 10·945 of its water. This large content of water at ordinary temperatures was not observed by Marignac, who probably dried the mineral in the bath without previous weighing.

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If we except the presence of alkalies in the Shetland mineral, its composition agrees with that from Traversella, and aids in entitling it to be considered a distinct mineral.

Dana conjectures that talc-chlorite may be merely "ripidolite impure from mixture with talc;" but the Shetland mineral in no way bears out such a view. In order to free it thoroughly from saline impregnation it was suspended in water, many times changed, and scales of one size taken for analysis. During the suspension it was carefully examined with a magnifier, and there was no appearance of the smallest admixture of scales of talc.

The small outstanding rock at this corner of the shore contains a small remaining portion of the vein of actynolite; as the finely tinted green crystals are here imbedded in lustrous white scaly *talc* (D and H.), the appearance of the specimens is striking.

Under the impression that this talc was Damourite it was analysed and yielded,

Silica	60·889
Alumina	4·143
Ferrous Oxide	1·24
Magnesia	28·085
Potash and Soda	traces.
Water	4·72
	99·077 (H.)

Its specific gravity was 2·825.

Specimens of actynolite rock here also contain plates of fine lustrous *Biotite*, and equally brilliant ones of *chlorite* (D. and H.)

The pinkish-red variety of *steatite* called "Klebber" is also found here (Hb.) Hibbert adds potstone, but he seems to have confused this, here at least, with precious serpentine.

The great amount of contortion which is to be seen about *Stack Sound* gives countenance to the hope that it might afford minerals; the rocks all around seemed inaccessible, except by landing from a boat. Dr. Gordon succeeded in procuring for me excellent typical specimens of the rock. Careful examination of these leaves no doubt in my mind that the rock is essentially the same as the zoned diorite already described as occurring at Colafirth; the only difference visible to the lens which I could perceive was the presence in the lighter-coloured layers of a considerable amount of quartz. This quartz imparts an unusual endurance to the albitic layers, which stand out in high relief, where the hornblende has been rotted out by the sea spray.

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The observation by Dr. Gordon of rocks very similar to those of Colafirth and Hillswick at the head of Roeness Voe, goes far to connect all these rocks with each other.

No finer illustrations of metamorphic rocks of an intermediate type could be pointed out than these schistose diorites of Colafirth and Hillswick. At Colafirth the metamorphism sometimes goes a step further, and the schistose character almost disappears. But here it is not so. The rock on the large scale is like a plicated gneiss; hand specimens show its components and arrangement of parts to be that of diorite, while in a mass of but a few inches in dimensions we have a condensed delineation of the structure of some 60 yards of the gneiss of Sutherland.

Under the microscope this rock shows the arrangement of the hornblendic ingredient to be somewhat peculiar; this, in form like grains of corn, is arranged in a somewhat plicated manner, their long diagonals being nearly parallel with the layers of albite; a red substance, doubtless garnet, is also present.

The first spot south of Cliff Sound where the cliffs can be safely descended is *Quin Geo*; this, being divided by a projecting point, must be scaled at two places.

In the *North Quin Geo* violet *fluor* occurs in octahedral crystals, imbedded in calcite, in a matrix which carries epidote. (D. and H.)

Epidote occurs here filling a small vein; it is in rich green crystals of over an inch in length, disposed in a stellate manner over the face of the rock. (D. and H.) The specimens are fine.

Its analysis yielded,

Silica	36·127
Alumina	20·574
Ferric Oxide	14·921
Manganous Oxide	·306
Lime	23·025
Magnesia	·306
Water	4 568
	99·827 (H.)

Rose quartz occurs here forming a smooth-sided vein (D and H.) The structure is here different from that which it assumes elsewhere in Scotland; being very massive, calcedonic, and almost hyaline; it appears to have been originally formed of a granular congeries of crystals little larger than shot, which have been so semifused into each other as almost to obliterate their lines of contact, and to be obscurely saccharoid. The cleavage is thus not rectilinearily continuous, and the mass is diaphanous but not transparent. The colour is pale but fine.

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In *South Quin Geo* several veins of a *purplish-pink quartz** occurs (D. and H.); the structure of these is massive fine granular; this quartz is sheathed by foliæ of a mixture of margarodite and chlorite; veins of quartz in a splendent mica slate here carry imbedded dodecahedra of brownish-red *garnet* (Hb.) which imparts a peculiar glandular-like structure to the quartz.

The bight immediately to the south of Quin Geo was named *Carneba* to the author, but as Hibbert mentions a number of minerals as occurring here, none of which were found by the author, while they were all found by him at the spot called Sandy Geo, which is not mentioned by Hibbert at all, there may be some doubt as to the correctness of the name.† At the *Carneba* of the map there were only found some *purple quartz*, and thin veins of a blue-black colour. These, on hasty inspection, appeared to be Lydian stone, on a closer, to be a matted mass of crystals of the variety of tourmaline termed *scorza*; while other portions appear to be a laminated mixture of hyaline quartz with some black mineral unknown. The veins also carry a very red compact felspar in imbedded crystals, with small quantities of radiating epidote identical with that seen in Quin Geo (D. and H.)

Almost at the most southerly point, at a spot called *Baalan*, a vein of crystals of actynolite, identical in appearance with that described as having occurred at Nidister, may be seen on the very brow, and cutting down the face of a beetling cliff. (*H.*)

Hibbert's statement regarding Carneba is "at a place named Carnebie, is much steatite approaching to the character of potstone, yet of a softer consistence, and of a brownish-purple red colour. Common chlorite is in junction with it, of an earthy foliated character, the colour of which is a brilliant dark green. Interspersed in this mass are numerous small octahedral crystals of magnetic iron ore, of a bluish-black colour."

Descending *Sandy Geo* with the aid of a rope, there are to be found all these substances stated to occur at Carneba. The massive granular *steatite* is of a peculiar reddish-yellow colour; the massive granular *chlorite* is in such intimate association with it, as to prove a close relationship to subsist between the minerals, or in their mode of formation.

That this is the spot to which Hibbert applies the name of Carnebie is shown by his notice of a most interesting and beautiful association of magnetite with ripidolite. Dispersed somewhat sparingly throughout the pinkish steatite are rosette crystallisations of ripidolite, the crystalline plates being disposed around a centre, like an opened out and completely

* Hibbert mentions "much of the substance of a very red compact felspar;" it is possible this compact quartz may have been mistaken for the above.

† Dr. Gordon has ascertained that my naming is correct.

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circular fan, and the centre of each of these rosettes is a perfectly formed and brilliant octahedral crystal of blue-black magnetite. As the plates of ripidolite are of perfect transparency and a brilliant dioptase colour; the specimens, though small, are of very considerable beauty.

This, being one of the purest looking ripidolites in Scotland, was analysed, and gave,

Silica	32·549
Alumina	13·95
Ferric Oxide	·972
Ferrous Oxide	5·275
Manganous Oxide	·156
Lime	·79
Magnesia	32·785
Potash	·48
Soda	·062
Water	13·173
	100·192 (H.)

There is here, as also at the adjoining geo, the same chronicling of names cut into the steatite as has been noticed as occurring at Fethaland. The Shetlanders call such places "The Klebber-names."

The cliffs are now intersected by porphyry, and inaccessible until the point denominated *Vanlup* is reached. Here the strata becomes more of the nature of mica schist, or of a mica schist in which the components are segregating apart.

In the quartzose belts of this rock very fine specimens of *kyanite* (Hb.) are found. These are of two varieties; in the one, belts of massive reddish quartz carry isolated bundles of diverging crystals of the mineral, which are very characteristically and beautifully disposed like plumes of feathers—the colour is here red, shading off into bluish or greenish white. In the other variety, masses of interlacing bundles of crystals unite to form large nodules, which lie bedded directly in the micaceous layers of the schists. These bundles are separated from one another at some points by bunches of crystals of *chlorite* and *margarodite*. The kyanite here is pale blue, or red passing into white, sometimes somewhat chocolate coloured.

The latter variety yielded,

Silica	38·153
Alumina	56·979
Ferric Oxide	1·867
Manganous Oxide	·153
Lime	·301
Water	2·646
	100·099 (H.)

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The matrix of kyanite at the foreign localities being Damourite, the glistening silvery-lustred plates associated with this kyanite, were analysed, under the impression that they too were that mineral. Their extreme softness during the picking them out, led to their being considered talc; the analysis shewed them to be *Margarodite* (D. and H.)

They yielded,

Silica	45·43
Alumina	29·65
Ferric Oxide	8·33
Manganous Oxide	·02
Lime	·79
Magnesia	1·7
Potash	6·94
Soda	2·27
Water	5·29
	100·42 (H.)

The specific gravity was 2·825.

In Greg and Lettsom's Manual of Mineralogy, under the head of Babingtonite there occurs the sentence—"In this country it has only been found in one of the Shetlands; it occurs in large irregular laminated crystals of a blackish-green colour imbedded in white quartz." This sentence is copied in somewhat briefer terms into many works; and, from the statement being somewhat more full in Allan's Mineralogy and in the above than in these, as well as from the single specimen upon which the statement was founded having been in the old Allan collection, the probability is that it was found by Dr. Hibbert, and presented to Mr. Allan.

The present writer has in vain attempted to find Babingtonite in Shetland; the toil that he has endured in "walking down" distant veins of white quartz has not been little, the white quartz of the islands has itself suffered considerably in consequence, and he has frequently fervently desired that the writer of the above sentence had, from the top of Rona's Hill, viewed the thousand-and-one inlets of these marvellously tortuous shores, and so learned the necessity of writing with precision and point, in indicating localities.

The question as to what the something was, which in Allan's collection had received the name of Babingtonite, possibly may be correctly answered by saying that it was one of two things—either the large laminated crystals of hornblende of a blackish-green colour which occur imbedded in white labradorite in Balta, or large laminated crystals of *chloritoid* of a blackish-green colour, which the present writer found imbedded in white quartz at Vanlup.

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The possibility that it was the first of these rests upon the fact that shortly after the Allan-Greg collection became the property of the Nation, the said specimen was found not to be Babingtonite, and was set aside as an ill-defined or inferior specimen of hornblende*; I have already shown that Hibbert mistook white albite for quartz at Colafirth, and he was quite as likely to mistake the labradorite of Balta for quartz.

The possibility that it was the chloritoid of Vanlup lies in the resemblance which that mineral bears to the dark-green laminated form which Babingtonite sometimes assumes, and to its being imbedded in white quartz.

Be this as it may, seeing that Professor Maskelyne discovered that the Allan specimen was not Babingtonite, and that the writer failed during several prolonged visits to Shetland to find that rare mineral when specially sought for, the pen must be drawn through the record of its Shetland occurrence; and, however much we may regret its temporary† exclusion from the list of British minerals, there is no little satisfaction in the knowledge that we are drawing the pen at this same time through a sentence, which should never have found a place in the literature of an exact science.

The *chloritoid* presents two appearances (H.); the first, which attracted attention from its colour, is thus described:—Occurs in quartz veins in the immediate vicinity of the kyanite and margarodite, and in the near vicinity of garnet, ilmenite, and specular iron. Its colour is clove or chocolate-brown. Lustre shining, slightly pearly. Streak greyish. Cleavage basal, perfect but somewhat interrupted; parallel to two lateral planes, imperfect and rough. Structure foliated. In rough lozenge-shaped crystals apparently monoclinic. Hardness 5·5 on the cleavage plane; 6· on the lateral. Brittle. Specific gravity 3·356.

It yielded,

Silica	25·363
Alumina	41·736
Ferric Oxide	3·895
Ferrous Oxide	13·932
Manganous Oxide	·919
Lime	·901
Magnesia	6·82
Water	6·571
	100·137 (H.)

* Professor Maskelyne, who kindly had a search made for this discarded specimen, tells me that, doubtless on account of its having been considered a worthless specimen of a well-known mineral, it has not been preserved.

† It is merely temporary. I have less regret in expunging the Shetland record, seeing that I have found Babingtonite in two localities in Scotland. The first, which I have analysed, is in a granitic mass near Tongue in Sutherland. The second, which shows a single well-defined crystal, is in diorite from the neighbourhood of Portsoy.

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An examination of the second variety shewed that the first was partially altered. Except in colour and lustre the description is the same. The colour of the perfectly fresh mineral is blackish-green to dark green; its lustre is more pearly; its streak was pale-greenish grey.

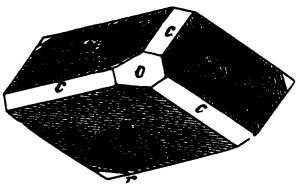
Its gravity ranged from 3·313 to 3·462.

On analysis it yieded.

Silica	24·47
Alumina	41·336
Ferric Oxide	·383
Ferrous Oxide	18·522
Manganous Oxide	·913
Lime	·302
Magnesia	6·80
Water	6·98
	99·706 (H.)

Both varieties invariably occur in imbedded rough crystals, and the green variety contains imbedded *sphene*.

The laminæ of all the rocks in this locality are highly contorted, the convolutions being shewn by extreme plications of the layers which are composed of a mixture of plates of margarodite and chlorite, with minute flakes of specular iron. Among these plates there occur the following minerals;—the two first, being interlaminated therewith obey the plications of their matrix. *Specular Iron* in thin plates, and rarely in crystals of the above (*o u c r*) form. (H.)



SANDY GEO.

The faces *u* are striated by an oscillation with *r*, or an intermediate face.

Ilmenite (H.) in blue-black plates, some inches in size, by about one-eighth in thickness. Its specific gravity is 4·916.

It yielded,

Titanic Acid	20·6
Silica	1·4
Alumina	1·443
Ferric Oxide	63·549
Ferrous Oxide	11·26
Manganous Oxide	·018
Lime	1·792
	100·062 (H).

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Rutile (H.) a single brilliant crystal non-terminated, but showing the prismatic faces M h l. *Limonite* pseudo after pyrite, in cubic crystals (H.) *Apatite* (H.) a single hexagonal crystal half-an-inch in width, of a beryl-yellow colour. Fine masses of high-lustred dark-green *chlorite* also occur (H.)

The quartz veins carry in their interior large plumose masses of pale-green *talc* (D and H.); also garnets in *d* crystals (Hb.); their colour is brown, they are much flawed or of a granular structure, and the crystals have rough faces. Granular *chlorite* also occurs in pseudomorphs after the smaller crystals of garnet (H.)

Hibbert writes of this spot—"a little to the north of Vanleep, talcose schist may be found much resembling mica, being of a pearl-grey colour, and remarkably unctuous to the touch. Its plates show a perfect want of elasticity. There is in union with it much *Steatite*. At the same place mica-slate appears of a very splendent lustre, being composed of thin pellicles alternated with plates of very pure white quartz."

The "remarkable unctuosity" and "perfect want of elasticity" indicates that Hibbert regards this as a well-marked sample of the so-called talcose-schist; "pellicles" which answered most completely to his description, and which were both remarkably unctuous and wanted elasticity, were therefore picked for analysis, and yielded,

Silica	45·421
Alumina	30·30
Ferric Oxide	6·874
Manganous Oxide	·816
Lime	·6
Magnesia	2·6
Potash	6·088
Soda	2·01
Fluorine	1·06
Water	5·011
	100·78 (H.)

This is *margarodite*, and thus we are accumulating evidence entitling us to hold—as that variety of muscovite was not recognised in Hibbert's time, while he admits that it much resembles mica,—that all Hibbert's talcose schists are margarodite schists.

The following point of distinction between talc and margarodite is direct,—when rubbed in the fingers, however greasy "pellicles" of margarodite may appear, friction merely reduces them to smaller and

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thinner pellicles; while talc, when similarly treated, rubs down to an inpalpable coating, the individual particles of which are not recognisable, from their minuteness.

This *margarodite* forms layers upon laminæ of the quartz, and occasionally hexagonal crystals are imbedded in the latter; the lustre is very high, but they have little or no elasticity.

Grariesum. About the divisional point between Vanlup and this, a few pieces of *Kyanite* were found, portions of which had a brilliant *azurite* blue colour, and these also had in small quantity a thin coating resembling *chrysocolla* (D and H.) *Garnets*, but of no beauty, occur here.

The late ardent mineralogist Mr. Copeland, of Blackwood, informed the writer that he found *green-fluor* on the west side of Sandwood bay.

The circles which indicate mineral localities have, in the map of Hillswick, been placed above the cliffs; this was done to prevent their being mistaken for the small stacks, of which so many environ the shore; the spots where the minerals are found, however, are either near the sea level, or on the slopes which descend thereto.

Eastward of Urie Firth there lies the large mass of the rock which Hibbert has called epidotic greenstone. This rock is of a very fine crystalline structure, usually of a dark-grey colour, but reddish where it approaches the rocks of Hillswick. Examined by the microscope it is seen to consist in largest amount of a felspar which is not distinctly striated,—augite,—and irregularly-shaped masses of a garnet-red mineral; this however, has not the fracture of garnet, but is either striated or fissured in a rectilinear manner, the fissures being equidistant.

This rock carries veins of a granite similar to that which forms the veins in the breccia of Colafirth.

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PAPA STOUR.

This island is considered in this place, as it is composed of the same rocks as those described as occurring in the south-west of Northmavine; however, we have in addition felsitic rocks and porphyrys which have burst through the bedded rocks.

The interbedding of porphyritic and amygdaloidal traps with Old Red Sandstone strata is well seen on the south shore of the island: the intrusive rocks are mostly confined to the west and north—they are very circumscribed in dimensions. The general dip of the sandstone is to the west in different directions, but almost always at low angles. Beds of volcanic breccia and conglomerate are not infrequent.

The porphyrys are of the soft "Claystone" variety, of red-brown or reddish-purple colours, with ill-defined crystals of red orthoclase and yellowish-white albite (?) sparsely distributed throughout the base.

The volcanic breccias contain in the more recent paste, portions both of the sandstones (often a conglomerate), and of the porphyrys.

The amygdaloid occurs in largest amount in the south-west at the Kirksands, and in the north between Ollas and Culia Voes; it is of a brownish-purple colour, often very vesicular, but the vesicles are small in size. These various strata of argillaceous and arenaceous sandstones, compact felspars, porphyrys, claystones, and amygdaloids, are intercalated in ever-changing order. The best sections are at Bordie and Ungly-braed Head.

The strata of this island being similar in themselves, similarly circumstanced, and acted upon by the same causes as those in operation at Northmavine, we have a similar or even a greater amount of ruin; here most strikingly exhibited in what might be called the cancellated structure of the island,—caves, arches and vaulted passages arresting the eye as it sweeps round the western shores.

The easily disintegrated rocks have, on the Atlantic side of the island, been cut into cliffs of considerable height. As the not infrequent alterations in the matrix of which the rocks are formed present various powers of resistance to the inroads of the sea, there has resulted the formation of a coast-line of striking features; this is always imposing,—it is only on account of a certain weirdness that it falls short of being magnificent.

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Professor Jameson has thus in general terms described it:—"The coasts are rugged and precipitous. Frequently the scenes are truly sublime; vast rocks of varying heights, dreadfully rugged and broken, oppose their rude points to all the fury of a tempestuous ocean; which in some places has formed great detached pillars, in others has excavated grand natural arches and caverns, that mock all human magnificence."

It is this *underground scenery*, indeed, which is of the most unique and surpassingly grand character.

A cave near Houseavoe is thus described by Hibbert:—"I entered in a boat a vault involved in gloom, when, after turning an angle, the water began to glitter as if it contained in it different gems, and suddenly a burst of daylight broke in upon us, through an irregular opening at the top of the cave. This perforation, not more than twenty yards in its greatest dimensions, served to light up the entrance to a dark and vaulted den, through which the ripples of the swelling tide were in their passage converted by echo into low and distinct murmurs."

The west coast from Hamna Voe to Culia Voe is shaped by the sea "into a continual recurrence of excavations."

Of these one is pronounced by no mean judge—Dr. Macculloch—to be *facile princeps* of the caves in Britain. It has been thus described—"when surveyed from the summit of the cliff it appears as a cavity of some hundred feet deep, and about 120 feet in length, being situated at a distance of 180 feet from the sea. It can be explored by means of a boat,—a labour that is only to be accomplished in the calmest weather. A large arch first presents itself, and, after rowing through dark vaults, the light of the sun bursts in from the lofty opening above—here the water is several fathoms in depth. The boat then pursues its gloomy course through another extensive perforation, which at length expands into an immense cavern where the light of the sun is wholly excluded. In the innermost recesses there is a steep beach, where the cave ultimately terminates in a number of ramifying dens."

The north-west point of Fuglöe has, however, been sculptured into a form which, for artistic effect, very much transcends anything which does not possess some measure of exposure to the light of day. Projecting in "pillared state" over the ocean, it has entombed in far-reaching recesses, both sea and air and the light of day. Like a many shafted cathedral-crypt, it stands with pediments set in seething foam. The heavings of the ocean, entangled in a labrinthine gloom, lash against each other in self-destructive effort, expending themselves in

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sound, which booms from the far-off depths with tympanitic ring, as if the superincumbent mass vibrated to the shock, and each pillar gave back its own metallic note. The swellings of the curling waves, not content with the contrast of their own colours, stream with fleecy foam upon the russet shaftings, exposing in their recoil a verdant mantling—"wrought by the hand which works unseen." The white flash of the sea-bird's wing seems almost to sparkle in the pitchy blackness of this hollow of the land,—whose "far-drawn aisles" present every possible shade in the contrast of light and darkness.

Truly here sea and earth and air, and motion, and colour, and sound seem to have conspired to surfeit all the senses.

The exploration of its unknown depths in a boat must be of singularly rare accomplishment:—both tides set right on to it,—it is a place of perpetual motion.

Minerals.

"On the south side of the island and also at Hirdy-geo there are small veins of *hematite*, these are situated in a bed of amygdaloid" (F.)

"At the south end of the Kirksands in an amygdaloidal claystone of a dark-liver colour, druses occur which are filled with *calcareous spar heavy spar*, *fluor-spar*, *quartz crystals*, *chalcedony*, and *green earth*." (Hb.)

The fluor was first noticed by Jameson.

Veins of red *sinople*,—iron flint—associated with chalcedony and *jasper* (J.)

The exact spot is the third igneous rock to the south-west of the Kirksands.

The *fluor* occurs in pale violet, and dark purple cubes.

The paragenetic minerals, arranged in the order of deposition, are —*chalcedony*, *quartz*, *calcite*, *baryte*—lastly *fluor* (D. and H.)

The green earth of Hibbert—"semi-indurated steatite" of Jameson, is *saponite* (D. and H.)

In separate druses *cockscomb baryte* occurs in fair specimens (D. and H.)

Red Heulandite rarely coats the druses in minute crystals (D. and H.)

A single crystal of white *stilbite* was found (D. and H.)

Psilomelane coated with *wad* occurs in the same rock, at the east end of the same mass which carries the fluor (D. and H.) They form two veins.

Saponite (steatite F.) also occurs at Bordie, Ungly-braed Head, and elsewhere in slaty felspar.

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The porphyry near Ollas Voe yields druses of *quartz* (Hb.)

Lying loose on the surface Hibbert observed masses of *glassy actynolite.*

From the same anchorage as that from which Papa Stour is examined two localities on the Mainland may be visited.

These are the banks of the hill of Aithsness where Hibbert observed veins of *Chalybite*; and Dale, where he found *compact felspar.*

There is good anchorage in Housa Voe, but the entrance is difficult. The following directions will, in the absence of a pilot, suffice:—divide the entrance into four parts, take the centre of the second from the north. The mark is—keep a white house at the top of the bay just clear to the south of a chapel, seen a quarter of a mile beyond it.

As a safe harbour from whence to visit all the district, none can equal a bight on the north side of Snarra Voe, on the opposite coast of the Mainland.

VEE SKERRIES.

A piece of rock from these skerries which was brought to the writer could not be distinguished from the peculiar mica-gneiss of Vanlup in Hillswick. It was a contorted mass, consisting of much translucent quartz with foliæ of margarodite, chlorite, and a little ilmenite.

SEELIE VOE.

From this fine anchorage the neighbourhood may be examined.

Within a mile to the west there is a large mass of granite, which extends to Gruting Voe, and also forms the east end of Vaila Island. It is of quite a different nature from the granite of the Roe district, being usually highly porphyritic, and consisting of a melange of crystals, in which a yellow felspar is prevalent. The Brough of Cullswick is built of this granite, as is also that of Burra Voe on the West Coast. So that probably a mass of the same granite may occur in that neighbourhood.

The west shore of the Voe consists of so confused an assemblage of granite, hornblende-rock and porphyry, that it probably might yield minerals similar to those of Hillswick.

On the east shore of the Voe thin veins of pale *pinkish quartz* coated with chloritic-schist are sparingly found (D. and H.) The quartz is massive granular in structure, and opaque.

On the south-eastern shore of Kirkaness large veins of what Hibbert calls *rose quartz* occur; the colour, however, is a purplish-pink, of

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by no means a delicate tint. The great size of the masses, however, and the somewhat effective manner in which a chloritic gangue is mingled with the quartz, renders these so far striking. We did not, however, find a single fragment which was in the least hyaline.

A very singular cleavage in two directions, yielding an angle somewhat near to that of hornblende, is a marked feature of this *purple quartz*. On the same shore we found granular *chromite* imbedded in green *serpentine* (D. and H.)

A protruding boss of granite, the components of which are unusually large in size, appears about midway between the Kirkaness shore and the south shore of Bigsetter Voe. From this boss large plates of twinned crystals of *Muscovite* are to be got (D. and H.)

Both in the shore at Kirkaness and on the South shore of Bigsetter Voe a porphyry apparently the same as that described as occurring in the north-east of Unst is to be found. There is perhaps a little more epidote, and the crystals of felspar have a redder and finer colour. Hibbert calls this rock epidotic syenite. There can be little doubt that it is the same mass as that which has been described as cutting off the Fitfiel Head schist from that of the Cliff hills,—which forms the islets in the Bay of Scalloway,—and which is probably continued in the islands of Yell Sound. It is at Kirkaness a beautiful rock, admirably adapted for monumental purposes, but so far as the writer could judge, has a tendency to separate into brick-shaped masses of small size.

Chromite, bedded in dark-green *serpentine*, has been wrought in the south shore of Bigsetter Voe: associated with it there occur veins of a brilliantly lustrous white felspar, which breaks with large flat cleavages, these being throughout besprinkled with a graphic lettering of hyaline quartz. No portion could be found sufficiently free from the quartz for such an analysis as would do more than qualitatively determine the felspar. There can be little doubt as to its being albite, and the occurrence of a *graphic albite* is probably new (D. and H.)

In the Burn of Tractagill on the opposite side of the Voe, near the junction of the gneiss with mica slate, on the slopes adjacent to Weesdale Hill, an extraordinary quantity of porcelain-earth lies accumulated, owing to the decomposition of the abundant quantity of felspar which the rock contains. "It is of a very yellowish-white colour, and its particles cohere but slightly to each other. The gneiss from which it is produced, appears to be decomposed in such a manner that the position of the strata is not disturbed by the change; for in the disposition of the layers of porcelain earth, I distinctly traced the line of direction and dip assumed by the undecomposed strata of contiguous rocks." (Hb)

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This "porcelain earth" would from the above description appear to be in all respects similar to that of Lumbhoga in Fetlar.

Hibbert makes the following most interesting observations on the gneiss of Selaness in Aith's Voe :—"In this may be observed a vein of felspar 6 feet in width, consisting of rounded spherical concretions, some of which are no less than 6 or 8 inches in length. They are often composed of felspar alone, but sometimes of quartz and felspar. In a few of them mica is very sparingly disseminated. I have described these portions of rocks under the name of concentrically laminar concretions. Each speroid in the vein is formed by concentric layers, inseparable from their nucleus, and these on account of the firm texture of the rock, are not to be traced without careful observation. In some of these concretions I have remarked that each concentric layer was formed by radiating matter, directed from the circumference of the circle towards the centre. The form of the spheroidal concretions is not always very perfect. Their figure is occasionally impaired by the junction, as if they had been pressed against each other whilst in a soft or yielding state; consequently a tuberculous form is sometimes induced."

This very much corresponds with the structure of the speroidal syenite—the Napoleonite of Elba; and I have seen a very similar structure well marked in two other Scotch rocks. The first is in the rock of the island of Ensay in the Sound of Harris. This rock is very much of the nature of the eklogite of Harris; it contains, however, less garnet, and kyanite is not manifest in it. Dr. Joass, of Golspie, sent me specimen from this island consisting of loose and also of imbedded concretions of radiating actynolite, the structure of which, as developed by zones of colour, is similar to that described. They are not, however, of so frequent occurrence in the rock as to impinge upon one another.

The other instance—a most unique and interesting one—is in the possession of Professor Nicol, of Aberdeen. It was found on the south side of Ben-na-chie in Aberdeenshire; the rock is a fine-grained granite, in the midst of which there lies, firmly imbedded in one-half of the specimen, a "concretion," of which the structure is both a radiating and a concentric arrangement of the constituents of the granite. The other half of the specimen shows the "cast" of the separated concretion.

Clay Slate and Old Red Sandstone Localities.

A stratum of limestone curves round from the north west of Rovie Head forming the dangerous rocks called The Brethren, and the islet of Greenholm; in both *Dolomite* occurs in simple crystals in cavities of the limestone (H.)

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Sandlodge.

About a mile to the north of this, the clay-slate contains *serpentine* with *steatite* (Hb.) "Among the strata of micaceous schistus which form the cliffs of Coningsburg crystallised *cyanite*" (J.) (kyanite) "of a white colour tinged with azure. Specific gravity 3·618.

The junction of the clay-slate with the unconformable sandstones may be seen a short distance to the west of the house of Sandlodge. Almost at the junction there is an old mine of *specular iron.*

The clay-slate where last seen at its eastern boundary assumes chloritic features, and consequently the overlying sandstone somewhat largely partakes of the same character. Hibbert goes so far as to speak of it in this locality as being a *magnesian sandstone*, adding that it has a steatitic character.

Many small calcareous veins traverse the sandstone near the junction, and a little way to the east of Sandlodge, a vein which at the surface seems nearly vertical, but which Dr. Fleming says dips to the east at an angle of 45°, has been intermittently wrought for iron and copper.

This vein occurs in "a reddish-coloured argillaceous sandstone" (F.); it strikes from north-east to south-west: near the surface the ores were chiefly those of iron; those of copper were found at a depth of twenty fathoms chiefly.*

*Professors Jameson, Fleming, Traill, and Dr. Hibbert have alike expressed themselves as having formed great expectations of this vein; Professors Fleming and Traill who minutely inspected the workings, have also alike expressed themselves as having had reason to be utterly dissatisfied with the mode in which it had been on every occasion wrought, and they alike assign the repeated ill-success which has attended the working of this mine to the incapacity and ignorance of the "captain of the mines."

Having examined this mine and its minerals on more than one occasion, having inspected the mode of working during a late attempt, and having had very special opportunities of testing the capacity of the management as regards the two points of following a vein, and recognising mineral species, I have to say that the opinion I had to form agrees with that of the afore-mentioned gentlemen, in at least the two first of the above three particulars. Having also had to come to the conclusion that the Cornish captains of mines who come to Scotland to exercise their function are, with hardly an exception, incapable, and so act a very detrimental part to all judicious mineral-enterpriset I conceive it to be fitting when such an opportunity as the present occurs, to direc, attention to the tact in its double bearings.

I shall therefore quote the opinions of Professors Fleming and Traill, and give my own experience.

Professor Traill, who visited the mine in 1803, during the time it was being wrought, writes:—"The miners had penetrated to a depth of about twenty-two fathoms, and were but little incommoded with water. At that time there were but two Cornish miners, besides a Cornish *Captain of the Mines*, engaged, and these were chiefly occupied in giving directions to the natives employed to work in the mine. The want of men sufficiently

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Dr. Fleming mentions the following minerals as having been noticed by him:—*Limonite, native copper, fibrous malachite, pyrite, chalcopyrite, siderite, fahlerz.* Dr. Traill added to this list *micaceous iron ore*; he specifies the limonite as occurring in the varieties of mammillated, stalactitic, and fibrous; also columnar bog-iron-ore and brown iron ochre.

The malachite he says occurs, friable and amorphous, "almost equal to the Siberian specimens, and in capillary radiating crystals;" (G. and L.) the latter occurred in such quantity in the twenty fathom level as "to afford a most beautiful spectacle by the light of our candles."

To this list the author has to make the following additions:—among the specimens brought by Dr. Traill from the mine, he recognised *psilomelane*, and also *lepidocrokite* in highly characteristic scaly, fibrous, and glimmering-lustred specimens. At the mine he, with Mr. Dudgeon, found long opaque crystals of *white quartz* crossing each other in a

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skilled in mining was certainly one cause of their failure. The principal manager was totally ignorant of the art of mining. There was iron in abundance all round. The roads near the mine were all paved with hematites, which the Cornish miners who were there did not seem to regard as of any value, or indeed almost to know. Some of them imagined it was a new kind of copper-ore. Some pieces of bog iron ore which I had collected, were called *copper spume* by one of them; hence it is evident we cannot trust much to the mineralogical opinions of the generality of miners."

Dr. Fleming, who visited the mine in 1808, thus writes:—"The principal vein is said to be nearly fourteen feet broad; none of the shafts have been sunk deeper than fifty fathoms. Brown hematite is found towards the surface in great quantity, and nearly occupies its whole breadth; the sparry ironstone appeared in plenty towards the bottom of the mine, and constituted the veinstone.

The copper-ore was sent to England, where the best of it, it was stated, was sold for £70 per ton. From the month of June, 1802, to the month of June, 1804, four hundred and seventy tons of this iron-ore were sent from this mine to Swansea. Still it is said that the mining company sustained a very considerable loss. Nor ought this to be a matter of surprise. The persons who have been appointed to conduct the work have frequently been men ignorant of the art of working mines, and of the nature and value of the ores which they met with. Many fruitless attempts have been made to find out new veins in the neighbouring rocks, even where no promising appearances presented themselves, whilst the depth and extent of the principal vein appear only to have been superficially examined. The manager or captain of the mine, who was still at Sandlodge, did not seem to be acquainted either with the composition or value of the sparry ironstone or of the hematite, though by far the most common productions of the vein. The difficulty of working the sparry ironstone or veinstones of the copper-ore was stated to me as the reason for abandoning the mine.

Mining operations under such management must generally terminate in confusion and disappointment."

Doubtless!

"Considerably" more than £33,000 expended in two years on a mine, the deepest galleries of which are but twenty-two fathoms, in which they have no water to raise,—nor an adit level carried it all off—and in which a fourteen foot vein is solidly plugged at surface with fine hematites, below with a "veinstone of sparry iron ore!"

How could they have done it?

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singular reticulated manner in cavities of ochry limonite. Powdery *wad* which was examined for cobalt, but found to contain no trace;—this was imbedded in cavities lined with crystals of pyrite. *Orthoclase* crystallised with *siderite*, crystallised *chalcopyrite*, and calcite in small *F.* crystals.

Mr. Dudgeon lately noticed in the Edinburgh Industrial Museum minute crystals of a fine green colour, and of a form somewhat similar to that of Brochantite, upon fibres of malachite from Sandlodge.

A minute quantity of these crystals were examined by the writer, and found to contain neither sulphuric, carbonic, nor phosphoric acids; but contained chlorine, copper, and water; they were fusible. The termination of the crystals was that of atacamite, but the position of one of the prismatic planes was new. Probably the mineral is *atacamite.*

Only in the way in which they did do it; by making roads of the fine hematites, and leaving the "veinstone" in sparry heaps at the pit mouth; for, hear Hibbert, writing in 1822:—"Adjoining to the shore is a pavement strewed over with the produce of the veins. Hematites and bog iron ore have made the road as black as Erebus, and caused it to resemble the vicinity of a smelting furnace. The mineralogist *will find some amusement* in examining the ores which lie in heaps near the old shafts; these have been by Mr. Bruce judiciously preserved; they present satisfactory indications of the contents of the vein, and may afford a criterion of the hopes to be entertained from any future prosecution of *the mining operations of Sandlodge.*" This peculiar phraseology is perhaps intended to be explained by his going on to tell us of the loss sustained during the drawing the £33,000 in two years.

Dr. Hibbert was not given to jokes,—that above is the only one in his book; geology and mineralogy were to him alike full of seriousness; but surely the staid writer inwardly smiled while making that—to him—unusual "find" among the heaps of ores; and we cannot but speculate as to whether the "find" of a new mineral there would, in all respects, have entailed more gratifiaction.

It was certainly not amusement which the writer experienced when he first saw a great heap of that "sparry veinstone"—hand-dressed during the extraction of the chalcopyrite; but it is fitting that he should express his satisfaction in being able to say that the knowledge of Cornish captains of mines has taken a great stride since the day when the hematites and the sparry veinstone were first rejected. Seventy-four years is perhaps a long time for one stride, but it is a beginning; on the second occasion on which he visited Sandlodge, he found that Mr. Bruce's judiciousness had been incontestably proved; the mines were again being worked, and the heaps of "fine hematites" having been sold, as much thereof as could be grubbed up had been removed.

The average Cornish Captain has therefore now attained to a knowledge of Limonite,—but not of Chalybite—not two strides! Chalybite is still above him; and he seems determined to possess himself of it in no way, for he has *buried it*; the tirring and rock from a new shaft having been thrown over it, leaving merely so much exposed as shows the heap still to be there.

When a freshly-broken characteristic specimen from the said heap was submitted to the person locally in charge of the late workings, it was with confidence, but seeming indifference, pronounced to be "a stuff called felspar."

I wish it to be distinctly understood, that in the above, I allude to such miners only as come to Scotland.

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Skewsbrough.

This "Brough," or "Pictish tower," stands on a knoll of *serpentine*, the only bit I was able to find in the district. This serpentine is of a rich green colour, with darker almost black markings, which interlace with one another like the cordage of a net. The colour and appearance are hardly to be distinguished from that of the rock of Towanrieff in Aberdeenshire, and they are perfectly indistinguishable from that of the finer varieties of the stone of the Greenhill of Strathdon.

A little to the east of this brough, veins of *iron-mica* of considerable dimensions, occur in the clay slate, they are associated with a belt, some inches thick, of a green nondescript substance—palpably a mixture, and probably one of the soapy allomorphs of hornblende.

The veins of ironstone may be traced first with an eastern trend, they then curve round the foot of the "Wart" (ward), assuming a northerly direction, and keeping near to the junction of the slate with the Old Red Sandstone grit, until they seem to pass into an old mine of limonite on the west shore of Levenwick.

The iron is throughout associated with quartz; at the south end *kyanite* (H.) and *ilmenite* (H.) rarely occur. Here the iron assumes the features of a bed or beds, but towards the north end it gradually crosses the line of junction of the secondary rocks, and in the Old Red Sandstone is evidently continuous with a vein which appears in the north shore of Hoswick, and which vein in its northern outgoing forms one or other of the Sandlodge veins.

The kyanite is greyish-white to pale blue; the ilmenite is in isolated rough thick crystals; both are imbedded in quartz.

The ilmenite yielded—

Titanic acid	21·11
Silica	1·63
Alumina	·364
Ferric oxide	66·321
Ferrous oxide	8·264
Manganous oxide	1·363
Lime	·211
Magnesia	·374
	99·637 (H.)

Its colour was brownish-black, and its lustre dull.

Black *tourmaline* occurs in crystals of half-an-inch in length in gneiss in the cliffs on the west side of *St. Ninians Island.* (H.)

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Sphene is found at *Altaness* in *Burray Island*, in porphyritic gneiss. (F.)—*Ed. Phil. Journ. Vol.* 4, *p.* 214. "*Rutile* occurs in small crystals imbedded in gneiss in Burray." (F.)

A vein of pyrite was worked near the junction of the clay slate with the mica slate at Garthsness near Fitfiel Head, for a doubtful trace of chalcopyrite; and in the clay slate at the Girths of Quendal, north of Fitfiel Head, a large vein of *iron mica* was at one time wrought. Its out-goings in the cliff are quite well seen, but it has been lost further inland: on one occasion when we were there, a "Cornish Captain" was engaged in making most successful efforts to prove that he was perfectly incapable of refinding it.

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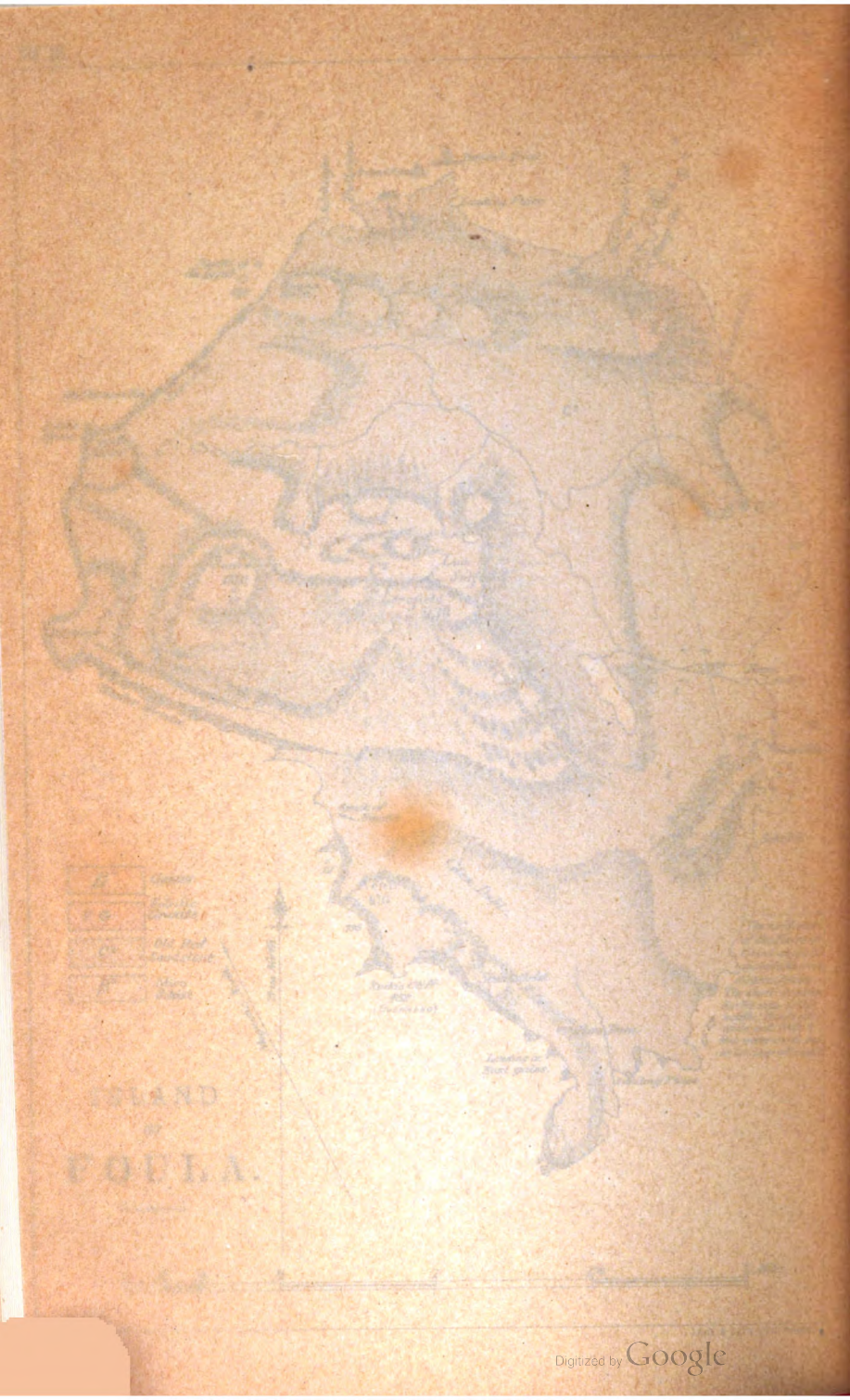

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ISLAND OF FOULA.

*"Here no man dies—for all their necks are broke."**

There can be no reasonable doubt that this was the island—the Ultima Thule—seen by Agricola, from Orkney.

From the islands of Westray, Papa Westray, and North Ronaldshay it is, from its over-topping height, and from its also lying more directly to the north,† much more frequently seen than the Fitfiel Head.

Jameson tells us that from the Mainland of Shetland, the island of Foula forms a "tremendous object."

Having well nigh exhausted his vocabulary in describing the cliff scenery of the main group of the Shetlands, this author apparently is in somewhat of a dilemma when he comes to consider those of this outlier. The precipices of the Ord of Bressay are termed "frightful"—those of Noss "tremendous"—the Noup "stupendous"—Fitfiel Head "immense"—the rocks of Æthsting and Sandsting "awfully grand;"—but those of Foula have produced so powerful an impression that they are characterised as "terrific" and "most hideous." This latter expression must, however, have been employed to signify the nervous dread with which they had been contemplated. In its ordinary sense the word certainly most unfittingly expresses the character of the Foula cliffs, which are light and graceful in their contours,—massing with one another in grand combinations, and cutting the upper-air with a skyline in comparison with which the Ord of Bressay and the Fitfiel Head are altogether "hideous."

This island in the altitude, grandeur, and artistic features of its cliffs, very much surpasses everything else of the kind in Shetland.

From whatever side it is viewed, Foula, from the suddenness with which its hills rise from the ocean and the high angle of their slopes, does certainly appear as a startling and "tremendous object." From a base of about a couple of miles in both directions, five hills reaching a height of nearly fourteen hundred feet, spring up with little, and, on one side, no intermediate slope. On their eastern and southern

* From a volume of *original* poems, which will well repay perusal. By James Disher, Stornaway.

† Its distance, some twenty miles from the main group, is the sole difficulty in visiting this island. In Shetland the dangers of *landing* on this island are regarded as nearly insuperable: in the island the dangers to be encountered in *reaching* it are equally dreaded. In average weather these dangers exist only in the imagination.

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sides these hills are steep; on their northern they can be scaled, but only by the employment of *all* the limbs; on the west they either drop plumb, or even somewhat overhang the ocean in the first part of the descent; and this they do with most sudden precipitancy, there being in many parts not only no preliminary slope, but not even a resting flat before the fall. From a steep and slippery grass-clad ascent upon the east, the rocks are cleft sheer down upon the west, leaving an edge so narrow that it must in some places be traversed in single file.

Though, from their vastness and from the nature of the rock, deficient in detail, yet for simplicity, chasteness of contour, and the effect of sublimity produced by their stupendous scale, these precipices as a group, stand unrivalled in the British Islands.

With Orkney and Shetland dim-seen in the distance,—with but a small circlet of land set in the midst of a wide expanse of waters at his feet,—with what is seen beneath of birds or crested waves diminished almost to airy nothingness, the spectator feels as if perched in space, and is thankful for that geologic faith which assures him that the perch is abundantly secure.

The five hills of Foula, enumerated from the north, are called Comma Field or Soberly, The Kaim, The Sneug, Lorafield or Hamnafield, and the Noup; it is a fair day's work to ascend all these hills and walk round the island.

Foula in the north and north-east consists of granite and gneiss. Hibbert mentions "slight indications of clay-slate having much the character of sandstone, into which it insensibly passes, so as to deserve little more than the name of argillaceous sandstone."

Also "slight indications of mica slate."

I did not find either of these rocks, but, in the south-east of the the island the sandstone at its junction with the other rocks, is of an ambiguous or ill-defined character.

This ambiguous rock extends from Schoble to a point called Granite-geo. Captain Veitch calls it gneiss. Hibbert classes it as sandstone. I regard it as an argillaceous sandstone much altered, in places converted into a grit or gneissic-schist, and have little doubt that there is here an actual transition from gneissic schists into rock of Old Red Sandstone age.

Starting on the circuit of the island at Ham, the landing place, we find in walking northward, the lower and more gneissic beds of this transition rock, to some of which the name of *millstone grit* might be appropriately applied, so far as expressing its physical structure goes.

The beds dip to the W.S.W. at an angle of 15° to 20°.

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They are cut off by granite,—or more correctly, there is a geo or fault twenty yards wide between them and the granite; the line of junction of the granite is E ½ S and W ½ N. The dip of the grit is altered to W. by S. with an angle of 30° just before the junction. Veins of the granite run along the strike, sometimes cutting the strata.

The granite is red like that of Roeness Hill, and must be more recent than the grit.

There supervenes a rock, generally a mica-schist, but sometimes a gneiss, through which veins of granite run along the strike of the strata, which, however, they sometimes cut. These veins consist of a pale granite, and, as noticed by Jameson, they are sometimes accompanied by veins of quartz.

At Sheep's Geo there are interstrata of hornblendic schist. The dip here is to the W.S.W., at an angle varying from 20° to 30° or more.

In these rocks there are nests of *green actynolite* (J.), and frequently *garnets*.

It has been stated that granitic veins run along the strike sometimes cutting the beds. The development of granite veins as seen in the low projecting tongue of rock which thrusts itself seaward, is the finest and most striking the writer has seen. The very peculiar form of this protruding mass of rock results from the way in which the rocks have been sea-worn at the junctions. Rectilinear and oft repeated lanes of water intersect the rocks, and, at all states of the tide, have cut off some rocky islets arranged in single file, and these are succeeded by sunken rocks. In these lanes or canals there is depth enough of water for a boat to traverse them, while they are so narrow, and disposed at such a distance from each other, that an active individual can proceed a considerable way seaward by springing from vein to vein,—the granite being generally the more enduring rock.

The junction with the sandstone takes place in a deep cleft called Wirwick. Although there is no granite here—except that of the veins, a very large one of which cuts the sandstone—the sandstone is much altered, having many of the features of quartzite, with a highly vitreous lustre. There is much contortion in the neighbourhood of the large granite vein. Unfortunately the cleft, which is floored by deep water, prevents this vein being traced into a connection with any of those which cut the primary rock,—here a mica schist.

Specimens of *red quartz*, disposed in blotches in the yellowish grey sandstone here occur. (H.)

The dip of the arenaceous rocks where in contact with the mica-slate, is to the south-south-west, at an angle of about 72°; and as when

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we pass westward we find the dip to be to the north of west at quite low angles, it becomes evident that there has been tilting.

That the tilting is in no way due to the mass of granite which tilted the strata at Granite Geo, is evident from the direction of the dip. There is no visible granite to the north-north-east of the gneiss; the dip of that gneiss at the extreme north point attainable at low water, is about 20°; at its southern extremity, just before its concealment under the turf, it is about 35°. It would therefore appear that the interstitial intrusion of the granite between the laminæ of the strata has *elevated it and the overlying sandstone in increasing amount as they passed southward.**

About the centre of the large open north bay the sandstone becomes very schistose and argillaceous, there are some thin strata of a dense blue impure limestone, and also of a singular micaceous "indurated" clay, with included bands of dense colloidal looking quartz which has filled up shrinkage cracks in the clay. These "cracks" being very much wider towards the centre of the mass than on the outside, a certain amount of septarian appearance is produced; but there is no honey-combing or circularity of arrangement. The structure is unique.

Following this, at the head of a small bight, there is some crushing, fracturing, and wedging, the origin of which is not apparent. There is the usual appearance of "induration," some little plication, and to the west, where the strata are again untroubled, the dip is more to the north.

The shores here commence to rise into cliffs with outlying rocks. One of these is of very singular form. This may be best conveyed to the reader by a comparison with a dog sitting on its haunches with its fore legs stiffened and its head erect; but the pillars representing the legs are much more massive than such a comparison conveys.

It is an insulated rock sloping rapidly towards the land, with its vertical sea face twice perforated by arched openings. One of these has pierced it laterally, while the second breach has, at right angles to the first, cut the prop into two.

As the rock is seemingly nearly two hundred feet in height, and the arches extend almost to the summit, it is a grandly imposing mass, beneath the dome of which an ordinary sized vessel, so far as space required is concerned, might easily pass.

Southward the sandstone is a loose grit. Its strata rise with extreme abruptness both from north and east, but especially from the former, into the ridge of Soberly, which overhangs the Atlantic in a

* The result being similar to what would be effected upon a bound book lying on a table, by the insertion of sheets of cardboard between the leaves.

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line of precipices. These looked along in fore-shortening view, present a number of knuckle-like undulations, trending towards the slope of the loftier summit, the Kaim.

The whole of this ridge overhangs; at its northern end the precipice has a height of 671 feet, at its southern of 724.

The ascent of the north side of the Kaim demands (except from a Foula man), the aid of the hands. The summit is a mere pinnacle 1211 feet* above the waters at its base; these are altogether invisible except to one who lies down and extends his body over the verge.†

The manner in which the summit of the Kaim towers, lighthouse-like, above sea and land, surpasses anything the writer has seen, excepting the Myling Head, in Faröe. This much resembles the Kaim, but he found its height to be 2337 feet, while Captain Born made it 2500.

The Sneug, the highest hill in the island, rises steeply in its centre to a height of 1379 feet; it descends with almost inaccessible slopes on the north into two valleys.

Lora Field rises to the east with a height of 1176 feet. Somewhere on the northern slope near the summit of this hill, there is a chasm covered with a flag; this is called the Lum of Snifield. We have Hibbert's and other authority for the statement, that several barrel-fulls of lines have failed to plumb this crevass; but the author and a party of five, two of them being Foulaese, searched for it for some time unavailingly.

The whole mass of these hills consists of loose arenaceous yellow, red, and grey sandstones, very deficient in cement; their upper strata are frequently micaceous, occasionally being rendered flaggy thereby; and they also contain granules of a green powdery matter, in ignorance of the nature of which we might call it *chloritic*, but it has more resemblance to glauconite.

Southward of this line of three hills, the island is cut down to a low level, and nearly divided into two halves by a wide trench called Glen Dahl.

Near the cliffs at the western extremity of this, there is an enormous cleft in the land of about six feet wide at the surface and perhaps thrice that below; it is 100 feet deep, and approximately 300 yards in length. The rent surfaces accord perfectly with each other; this

* Captain Veitch made it 1233 feet.

† By so doing he will to the right observe a lower projecting point called the Little Kaim—say 500 feet high. This the writer was informed is "a terrible place for fools," the English of which is *an unrivalled place for catching birds.*

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cleft runs at right angles to the line of coast; it has on the one side the three great hills last named, and on the south the huge towering mass of the Noup. Crevasses similar to this, but running parallel to a cliff line, frequently in Orkney give evidence of a coming fall—the sea having sapped the foundations,—but what has been the force which has operated here with such mighty buttresses on each side?

The precipices being here low, the cliff foot is seen to run out in bluish-black slabs, which dip to the S.W. at an angle of 12°; and, as on the south side of the Noup, the whole hill is seen to overhang to the south at a considerably greater angle, it is probable that this overhang, with a slip, has occasioned the rent.

The Noup rises from the Glen of Dahl—steep, smooth-sided, round topped, and lumpish, to a height of 822 feet. Its domed summit slopes slightly towards a rough-edged precipice of nearly equal height; the hill falls with dangerously steep slope on the south, and terminates in the Ruskie Cliff, 452 feet in height.

The upper portion of this precipice at one spot overhangs to an extraordinary extent, projecting over the waters in a huge protruding mass of jointless rock, which constitutes nearly half the bulk of the precipice.

South of this the shores are lower; they exhibit long projecting shelves of rock all dipping to the S.W., and appearing from above—for they are inaccessible—somewhat like the argillaceous flags of the Old Red.

Returning to the east shore, we come again upon the gritty beds, and find their junction with, or rather transition into dark argillaceous and micaceous schists, to occur at Schoble. There is no unconformability. Here the dip is at first low, but it rapidly rises until at Ham Little there is a dip of 45° to 50°.

Sailing under the tremendous wall of cliffs of Muldi-couse, Wester Hyvda,* and the Kaim, two parallel and synchronously flexured bands of yellow and black striped rock, are to be seen about mid-way up the face of the cliff. These may each be about 80 or 90 feet in thickness—were it not for the abruptness of the flexures, they would have been set down as bedded traps.

* Wester Hyvda has in its centre a sloping bank of tufty grass of treacherous attachment to the rock; it is this sloping bank which is so dreaded by those men who, according to the Stornaway Bard, never die, though all get their necks broke. While standing on the summit of the Noup our party was startled by a sudden report;- turning at the sound in the direction of Wester Hydra a quantity of thin smoke was observed somewhat rapidly disappearing, a mass of fallen rock had by the tremendous blow been largely dissipated into sand

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There is no spot where a cross section can be seen, but it is somewhat doubtful if the upper arenaceous beds are conformable with the flaggy layers.

Dr. Fleming mentions *Bituminous shale*, accompanied by thin beds of clay ironstone, as occurring, but does not specify the spot.

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FAIR ISLE.

This mid-ocean stepping stone between Orkney and Shetland is, with its outlying stacks, composed solely of sandstones and sandy grits.

As it lies in the line of a continuation of the long strip of sandstone rocks of Shetland, and altogether to the east of a line connecting the two groups of islands, it is to be regarded as belonging geologically to the latter of these groups.

The same conclusion is borne out alike by the bold and bossy character of its shores and hills, the nature of the rock itself, and the occurrence of a copper vein with a north and south strike, which may not improbably be the continuation of that wrought at Sandlodge.

The island is by some considered to derive its name from its being situated in the *fairway* between Orkney and Shetland: by others from its having for the most part cliffy shores unincumbered with rocks; but to the writer it appears that in all probability the name has been a corruption from Far-öe—a Norwegian appellation which we still have both north, south, and east of this.

It has the enviable or unenviable celebrity of having arrested the galley of the Duke of Medina Sidonia, the Admiral of the Spanish Armada in his last desperate attempt to regain his country, after the destruction of his fleet. It has blocked the fair-way from the continent to America with like destructive result to many vessels up to very recent times; and from the thin mists which frequently cling to its heights, it must continue to do so until its claim to be the site of a a lighthouse of the first-class comes to be recognised.

With the exception of a little low ground in the south, the island is altogether of considerable elevation; and it is so girt with cliffs that there are but three landing places on its shore, two on the south, and one on its north-east in a somewhat land-locked bight. No one of these, however, is practicable in rough weather, unless the wind be off-shore.

In the north-easterly bight a small vessel might lie at anchor, with southerly winds.

It has been stated that a vein of copper-ore occurs in this island—it is on its west side. Though this has been lately attempted to be wrought, it was never properly explored; and it doubtless would yield several species besides those which have yet been noticed, if it ever came to be thoroughly opened up.

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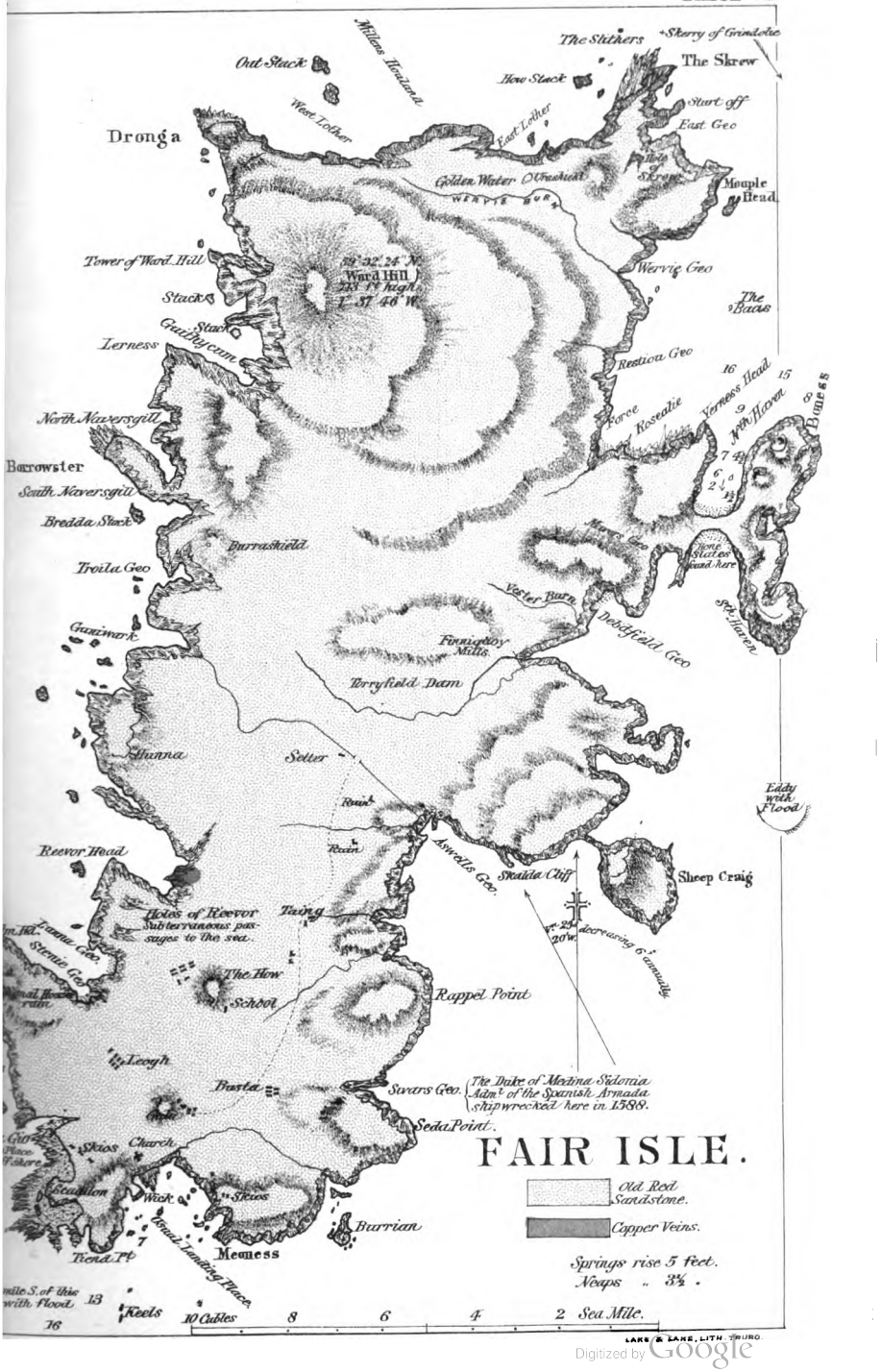

LAKE & LAKE, LITH. TRURO.

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That most irrepressible naturalist the late Dr. Fleming, thus describes it, at its northern locality :—" it is situated in a mural precipice of sandstone, upwards of 300 feet in height, to the northward of Naversgill, and directly exposed to the western ocean. This vein intersects the strata in a perpendicular direction, and the line of its bearing is from north to south. Both sides of the vein seem to be composed of greenstone, and in the middle of the vein there is a stratum of soft decomposed rock, containing much clay and fragments of compact *heavy spar*. The principal ore is the *copper glance* or *vitreous copper-ore*. There is also a small quantity of *copper green* and *malachite*, disseminated through the copper glance. The vein of ore appeared to be only about six inches in breadth; but as at the time I examined this vein I was necessarily suspended by a rope from the top of the precipice, held by two of the natives, and was furnished with no other instrument than a hammer, I was unable to clear away so much of the decomposed matter as to enable me to get a distinct view of the magnitude of the vein, or the quantity of ore which it contained; and as the surge below prevented me from approaching the vein in a boat, my observations were necessarily confined."

Two specimens were brought to the writer from this spot by a nephew. The first was a massive vitreous ore which had much more the appearance of *fahlerz* than of vitreous copper.

The second was a peculiar fine granular yellowish-white stone of low gravity.

In a hasty and altogether incomplete analysis it yielded 4·97 per cent. of a yellow matter infusible in Fresenius, flux. The portion which dissolved in the flux yielded,—

Silica	51·825
Alumina (with some Fe^2O^3)	31·935
Lime (with some Ba O)	12·1
Magnesia	4·4
	100·26 (H.)

This may be only a gangue; but I have seen a substance indistinguishable from this from one of the Orkneys, where it carried malachite and azurite in cavities.

The same vein appears at the head of a wider geo to the east of Reevor Head, at a more southerly spot on the same western side of the island. Here it is nearly altogether concealed on account of explorations conducted in a quite trifling manner.

The island indeed has never been properly explored.

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In the rocky shores of a small bight which is separated by a shingly beach or "ayre" from the little harbour of the east side of the island, *hone-stones* of considerable excellence are obtained.

The vast difference in the force of an Atlantic and of a North Sea billow is well displayed in the inequality in height of the cliffs on the west and on the east of this island. Among the interesting scenes of its intricately cleft shores, subterranean passages to the sea near Reevor Head, and the Screw or north-east point may be specially noted.

Some opinion as to the Geological age of these Islands may be expected before passing from a county which affords such unrivalled facilities in its winding shores for the examination of its rocks, which has supplied so many of the constituents of these rocks in such a state of purity as to be fitted for chemical examination—so many of these in those varying allomorphic conditions which afford every facility for change, and finally not a few localities where change incipient and complete is to be seen.

There are two directions in which correlation may be extended. First, with the rocks of the country in which they occur, or the rocks which the observer has himself examined; and secondly, with such as he draws his acquaintance with from the descriptions and writings of others. On the first of these points the writer is prepared to speak with such an amount of decision as is warranted by a close study of the older rocks of his country during many years; on the second, if he must speak at all, he does so with what he believes to be a very unusual amount of diffidence.

Such questions as these can only be entered upon after a due familiarity with the *literature* of the science; and, apart altogether from our ordinary acceptation of the signification of that word, Geology may be said to have a literature of its own, composed of sentences, words, and letters, as all other literature is.

In this special literature, *elements stand for the letters, minerals for the words, and rocks for the sentences*:—a thorough knowledge of these is as necessary for the proper compilation of the literature of geology, as is a knowledge of sentences, words, and letters to the proper appreciation of the structure of any written language; and yet it may freely be said that in much of the literature of Geology, there has not been over much deference paid to the importance of such knowledge.

Yet when the geologist steps from the fossil-bearing strata, to metamorphic and azoic rocks, such a knowledge is imperatively required.

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How are the sentences to be construed and their import unfolded without an adequate knowledge of and acquaintance with their form of construction ?

"The question here arises whether in the absence of organic remains or of stratigraphical evidence, there exists any means of determining approximately the geological age of a given series of crystalline stratified rocks; in other words whether the chemical conditions which have presided over the formation of sedimentary rocks have so far varied in the course of ages as to impress upon these rocks marked chemical and mineralogical differences. In the case of unaltered sediments it would be difficult to arrive at any solution of this question without greatly multiplied analyses; but in the same rocks when altered *the crystalline minerals which are formed, being definite in their composition, and varying with the chemical constitution of the sediments, may perhaps to a certain extent become to the geologist what organic remains are in the unaltered rocks—a guide to the geological age and succession.*"

Geologists who are about to enter upon the study of the older rocks would do well to ponder on these words of Dr. Sterry Hunt; they would also do well to give due weight to the correct chemistry enunciated in the following, from the same author.

"In the case of the permeable or more highly siliceous class of sediments, whose chief elements are silica, alumina, and alkalies, the deposits of different ages will be marked chiefly by a progressive diminution in the amount of potash and more especially of the soda which they contain.

In the oldest rocks the proportion of alkali will be nearly or quite sufficient to form orthoclase or albite with the whole of the alumina present; but as the alkali diminishes, a portion of the alumina will crystallise, on the metamorphism of the sediments, in the form of a potash mica, such as muscovite or margarodite. While the oxygen-ratio between the alumina and the alkali in the felspars just named is 3 : 1, it becomes 6 : 1 in margarodite and 12 : 1 in muscovite. The appearance of these micas in a rock denotes then a diminution in the amount of alkali, until in some strata the felspar almost entirely disappears, and the rock becomes a quartzose mica-schist. In sediments still further deprived of alkali metamorphism gives rise to schists filled with crystals of kyanite or of andulusite, which are simple silicates of alumina, into whose composition alkalies do not enter; or in case the sediments still retain oxide of iron, staurolite and iron-alumina garnet take their place. The matrix of all these minerals is generally a quartzose mica-schist. The last term in this exhaustive process ap-

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pears to be represented by the disthene and pyrophyllite rocks, which occur in some regions of crystalline schists."

Being at total dis-accord with Dr. Sterry Hunt as regards the origin of serpentine, it is a source of satisfaction to me to be able to point to the above as forming, in my opinion, correct leading-lines in geological speculation; and I cannot but lay special weight upon the occurrence—if it be a clearly well-marked occurrence of certain mineral species, as being a sure guide in correlation. Such occurrences must go far to prove both a general identity in the composition of rock masses, and a general similarity in the circumstances in which they have been placed, and in the agencies which have affected them.

Making use here of the above leading-lines, the writer in answering the first of the questions propounded, has to say that (excluding the sandstones lying to the east of the Cliff hills, and the sandstones with intercalated igneous rocks of the west coast), the older rocks of Shetland (though some small masses of strata may resemble those of other districts of Scotland), *form a group which occurs nowhere else in the northern division of the kingdom*

The similitudes referred to within the brackets, were pointed out at the time, and dwelt upon with all due, perhaps even an undue amount of force. These were, first, the resemblance of the Blue Mull and Fitfiel rock to that of Glen Rinnies and elsewhere, in Banffshire; and, second, the very startling fact of the almost identity of the serpentines of Colafirth with those of Portsoy, in appearance, bulk, and strike; but as regards the last, here the resemblance ends, for while the dip at Colafirth accords with that at Portsoy, the latter is seen to be the normal dip, while that at Colafirth is not the normal, but hades away from an eruptive rock. Little weight moreover could be laid upon an identity of dip at distances so extreme.

While then the above resemblances exist, they may perhaps be held to be no more than resemblances, when full consideration is given to the following facts.

The schist of Banffshire is rendered typical by the presence of andalusite, chiastolite, staurolite, and kyanite: the Shetland rock never contains these, though two of them occur in the neighbouring gneiss.

The rocks associated with the serpentines of Colafirth and Portsoy, though through the crudeness and bareness of lithological nomenclature bearing names nearly identical, are in their nature altogether dissimilar. The Colafirth rock is a markedly schistose *albitic* rock, the Portsoy one a porphyritic *labradoric* one.

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So much for resemblances. The points in regard to which the Shetland group differs from the rocks of the mainland of Scotland, are these—

The general strike is not the same.

The prevailing dip is in the opposite direction.

The gneissic rocks are markedly deficient in felspar, and, when micaceous, invariably carry margarodite or muscovite, and only in one locality, an altogether trifling amount of Haughtonite or Lepidomelane.

The hornblendic beds of gneiss are super-imposed on those which are micaceous—in them the ingredients are usually arranged in markedly separate belts—the quartz almost disappears, and the felspar is *albite*.

The more perfectly schistose rocks are largely composed of allomorphs of hornblende, which ingredient, in its physical properties, then much simulates a magnesian mineral; while it very frequently shows itself as undergoing or having undergone a serpentinous change.

As a group they are signalised by vivid colours, considerable unctuosity, a highly crystalline structure, consequent brilliant lustre, high apparent metamorphism, and great age. They are also locally much disturbed by intrusions of large masses of igneous rocks.

Correlated with the rocks of Scotland, they do not appear quite so ancient as the hornblendic gneiss of the west coast, but markedly more highly metamorphosed than the conglomerates, schists, and gneissic rock which overlie that gneiss; there is therefore no class of rocks in Scotland with which to correlate them,—the Banffshire rocks seeming less old than they.

When we go further afield in our correlation, we have to cross to that New World, which, in geological age, is the Old; and in Dr. Sterry Hunt's description of the Upper Huronian system, with its hornblendic greenstones, with chlorite, steatite, serpentine, and soft margarodite schists, with occasional clayslate and magnesian limestone, I see a system so singularly according with the rocks of Shetland, that I believe that geologist would assign them to that horizon, —members of which he has already recognised in Perth and Argyle Shires.

Should the conjecture of Murchison and Geikie that the gneiss of the west coast is of Laurentian age prove to be correct, (as indeed there can be little doubt,) and should the Shetland rocks with equal correctness be assigned to the Huronian, then in the philite schists of Boharm and Clova, the andalusite schists of Coreen, the staurol...

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and andalusite schists of Kinnairdy, the quartzites and limestones of the Vale of Deskford, Ben Cullen, and away to the south, the serpentines, granular hornblendic rocks, chiastolite, and margarodite schists of Portsoy, we have another series equally accordant with the Taconian of America.

This latter correlation, however, if the gneissoid rocks of the middle and east of Sutherland are truly Silurian—which is open to doubt—would call for an immense upthrow in the line of the boulder-filled valley of the Spey; but it has to be noted that an identity in the gneissic rocks, which lie to the north and the south sides of the great Caledonian Canal rent of Scotland, has never been shewn to be undoubted.

ADDENDUM.

Having directed Mr. Webster's attention to Dr. Fleming's notice of the chromiferous magnetite occurring *in limestone*, near the Loch of Trista, in Fetlar, he kindly made search and found the limestone.

It rises on the north shore of the loch, five or six feet above the level of the water, and crops up for some distance north of the loch. Mr Webster states that it stretches in a line midway between Hamma's Ness and Urister,—the peculiar appearance of the sahlite of which latter place induced the author to suspect the near presence of lime.

The Trista limestone contained the magnetite in minute angular specks. The specimens sent me by Mr. Webster consist of a yellowish, granular, loose-structured limestone, which carries an abundance of Biotite or phlogopite, and the magnetic mineral,—but no sphene.

According to Greg and Lettsom *andalusite* occurs in mica-slate in Unst.

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VI.—*Preliminary Notice of Substances which may prove to be New Minerals.*

By Professor Heddle.

Paper First.

At Mr. Collins's request I submit to the members of the Mineralogical Society the following preliminary notice of substances which I have collected during my somewhat extensive wanderings about Scotland.

In the case of several of the substances described, it will be seen that I do not by any means bring them forward as being without doubt *new minerals*; of that, I have not satisfied myself, and still less can I hope to satisfy others, until specimens more fitted for absolute determination are obtained, and that in a quantity larger than what I have as yet had to operate upon.

The noting and describing these substances now, will enable others to lend their aid in the work.

It may be convenient to begin with such as occur in the northern counties, and in the present paper I confine myself to those found in the shires of Sutherland and Ross.

The names are of course to be held as being provisional.

Bhreckite (Vreckite.)

On the western slopes of the hill of Ben Bhreck, near Tongue in Sutherland, there lie, imbedded in till, two boulders of syenitic granite, which probably were derived from the neighbouring mountain of Ben Loyal, the rock of which is identical with that of the boulders.

One of these boulders was crossed by a granitic vein; this vein yielded in itself as many minerals as are frequently to be found in a whole county.

Being an exfiltration-vein the ingredients had crystallised in regular sequence from the sides, leaving here and there very small vacuous spaces in the centre; and the substance, to which I have attached the name of the hill, was one of the last, if not the very last to be deposited in these cavities.

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It occurred in such very small quantity that nearly the whole had to be employed for the analysis.

The substance was deposited upon the surface of crystals of brown quartz, and its immediate associates were specular-iron and a calcareous strontianite.

In appearance it resembled a very fine-grained dense aphrosiderite; but its colour, being a light apple-green, was nearer to that of celadonite.

It was minutely granular or scaly; it was soft and friable.

What was analysed was to all appearance uniform and pure.

The analysis, executed on ·484 grammes, yielded,—

Silica	34·917
Alumina	7·158
Ferric Oxide	12·713
Ferrous Oxide	2·105
Manganous Oxide	·414
Lime	16·082
Magnesia	8·264
Water	17·768
	99·421

Of the above water 1·033 was lost at 212°.

There were traces of alkalies, but there was not enough material to determine them upon, separate quantities having to be used for the determination of the ferrous oxide, and of the water.

The mineral was freely soluble in chlorhydric acid.

By this feature it may be distinguished from all the so-called "chlorites," with the exception of glauconite; it likewise serves to distinguish it from celadonite.

From Delessite and the scaly varieties of saponite (which are soluble in chlorhydric acid), it differs in virtue of its large content of silica—a feature of its constitution which also serves to distinguish it from glauconite and the chlorites alike.

The calculation of its atomic constitution is as follows:

		Atoms.			
Silica	34·92	1·164		8	36·28
Alumina	7·16	·14	·3	2	7·78
Ferric Oxide	12·71	·16			12·1
Lime	16·08	·574	1·04	7	17·69
Magnesia	8·26	·413			8·46
Water	17·77	1·974		13	17·69

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Atoms.

$$\dot{R}\ 7,\quad \ddot{R}_2\ 2,\quad \ddot{S}i\ 8,\quad \dot{H}_2\ 13$$

which give the percentages of the last column.

This is the only chlorite-like mineral which contains lime in quantity; if established as a species, it will stand next to chonicrite, and in composition it is not far removed from the metaxoite of Asp.

Xantholite.

Chondrodite is stated in several works to occur "near Loch Ness."

Loch Ness, being twenty-four miles in length, must certainly have fifty miles of shore, so that "near" is not very precise. The sentence is, however, not more deficient in precision than are many others in mineralogical directories.

It is true that the adjunct "in limestone" would appear to convey in the present case all the necessary information,—limestone being of very exceptional occurrence in the district in question, and only being found in quantity at one spot,—the Milltown of Glen Urquhart.

Neither Professor Maskelyne nor the writer could satisfy themselves that the one known specimen of "chondrodite from Loch Ness"—that in the British Museum—was that mineral. To the writer it appeared to be yellow serpentine; and, had it not been for the concomitant presence of arsenical-iron, he would without hesitation have said that the limestone matrix was that of Glen Elg.

In vain has he on several occasions sought long and diligently for chondrodite, both at Loch Ness, and in other limestone localities, but last summer when he in company with Dr. Aitken found the substance to which the above name is given, he believed that it had at last been found.

The mineral occurs a little to the east of the Free Church of Milltown, in a singular rock composed of large crystals of smaragditic edenite and a matted mass of interwoven plates of a highly calcareous Biotite, which much resembles talc.

Accessory minerals are fibrous Wollastonite, hydrous anthophyllite, currant-red garnet with minute imbedded zircons, and the mineral in question.

This occurs in rough crystals of the size of beans, so wrapped up in the Biotite as to appear to be nodular. When broken, the colour is seen to be intermediate between that of rosin and of cinnamonstone; when the mineral is bruised it has still more of a yellow tint. It is fissured throughout, but there is one very evident cleavage; the fracture is conchoidal, and the lustre of the fracture vitreous, but that of the cleavage

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face is slightly pearly. The hardness is greater than that of the knife; but, from a minute amount of the Biotite lying in the fractures, it seems to be cut with the knife. It is reduced to powder with an amount of ease which, when its extreme hardness is considered, is singular.

No sound portion large enough for the determination of its specific gravity could be found.

The mineral was picked with extreme care, but the portion analysed might still have contained an inseparable trace of the Biotite.

Two analyses were made of the same quantity picked,—the first on 1·25, the second on 1· gramme.

There was obtained—

Silica	27·04	27·2
Alumina	45·858	45·965
Ferric Oxide	8·671	8·607
Ferrous Oxide	6·904	6·91
Manganous Oxide	·56	·5
Lime	3·808	3·528
Magnesia	4·32	4·5
Fluorine	·087	n.d.
Water	2·88	2·874
	100·128	100·084

It lost at 212° 0·64 of the water.

The only decided difference between the above and *grenatite* lies in the presence of lime and magnesia, and seeing that it is only lately that the presence of *both* oxides of iron has been noticed in grenatite, and that the formula of that mineral is hence still doubtful, it cannot be said that *this* might not, so far as composition is concerned, fall under the same formula.

What I have been able to make out of its crystalline form, however, points to its being distinct.

I have said that the nodular masses are rough crystals; such as I have been able to separate from the investing Biotite, seemed to indicate an oblique form.

The larger crystals are sometimes penetrated by smaller ones, which I at first took for zoizite—a mineral which occurs within a mile of the locality. Several of these penetrating crystals, however, having the same colour as the larger masses, I was inclined to think them pseudomorphs, until upon breaking them out I found that they had a perfect cleavage, with well-defined conchoidal fractures with a vitreous lustre.

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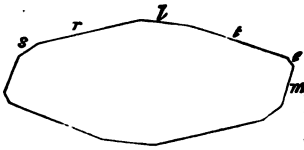
These crystals, which occur of a resinous and also of a dark-green colour, are very minute. Examined by the microscope they have in section the form drawn. This, if not that of epidote, is very close to it; *l* sometimes instead of being a plane is a series of oscillations between *t* and *r*. The letters are appended conjecturally merely to show the position of *m*, which has a very perfect cleavage with a pearly lustre. There also appears to be a cleavage parallel to *l*, and the general lustre of these minute crystals is resinous.



On account of their want of size, I have not been able either to try the hardness of these crystals, or to attach them to the goniometer; their being the same substance as that analysed rests therefore only on extreme probability.

If they be the same, the material of *grenatite* is dimorphous, and calls for a second characterising name; the *colour* being here the most characteristic distinction, I have named the substance therefrom.

Dr. Aitken has lately found this substance of a somewhat redder tint at a locality about half a mile from that at which we first found it; this is in the cliffs of a small stream, north of the village of Milltown. Here the mineral was only in nodules, these were much fissured; the cracks were filled with a soft white steatite-like substance; this remained with a reticulated structure when the fissured mineral was dislodged from its grasp. A little Wollastonite was also here present.

ABRIACHANITE.

This substance, which I name from one of the localities in which it occurs, was forwarded to me for examination by Mr. John Horne, of H.M. Geological Survey. The portion sent was, I understand, found by the members of the Inverness Field Club, during one of their excursions.

As Mr. Horne was not able to put in my hands a sufficiency of material for a complete examination, he referred me to our fellow-member, Dr. Thomas Aitken.

Dr. Aitken sent me a further supply, but inasmuch as from the nature of the specimens as ordinarily collected, they were not fitted for analysis, I found it necessary to visit several of the localities, under Dr. Aitken's guidance; I there collected the varieties of the mineral with my own hands, and was thus enabled to obtain it in as great a state of purity as was possible.

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Dr. Aitken having undertaken to supply the history of the mineral as regards its localities I need say little on that head.

To myself the modes of its occurrence appear so unusual and inexplicable, when considered as a whole,—that a few words on the geology of the district are desiderated.

So far as I know it is confined to a geographical limit of about six miles square, this square lying to the west of the town of Inverness, at a distance of about six or seven miles.

The chief rock of this district is a gneiss, which has been assigned to Silurian age.

It is a rock altogether ill-defined as a gneiss, is very argillaceous, and one which for a north-country rock has suffered but little metamorphism.

Overlying this gneiss, in about the centre of the district in which the mineral is found, there occurs a bossy outlier of the Old Red Sandstone conglomerate. Outwardly, it rises in craggy knolls; inwardly, it consists of much-rounded and marvellously diversified nodules of rocks, which had been markedly more highly metamorphosed than the underlying gneiss.

A few miles westward of the flanks of this mass of conglomerate there occurs a very circumscribed hill of red granite of a fine grain; this granite is somewhat hornblendic in composition, it is different from any other granite which I have seen in Scotland.

Between the granitic hill and that part of the gneiss which is overlaid by the conglomerate, the gneiss is considerably brecciated, and it is occasionally riddled by granite veins, these being however of a nature totally dissimilar to the red granite of the western hill.

Where the gneiss approaches the conglomerate the breccia is quite loose, hardly coherent in its parts, being quite open in its structure, and undergoing rapid ærial decomposition.

The arrangement of its parts does not in any way convey the impression that it is a fundamental breccia of the Old Red formation.

In the northern portion of the space indicated, there are bands of a poor limestone, with interbedded Steatite and Saponite.

It may be almost said that the gneiss, the rotting breccia, the granite veins, and the vein-stone of the lime, are alike saturated and pervaded with the mineral described; this, from its colour, has for a year of speculation as to its nature, been called "the blue mineral."

The specimens furnished me by Mr. Horne were of two sorts.

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The first consisted of shattery and sharp-angled fragments of the dull brown and muddy looking gneiss, on the surfaces of and filling the many rents of which there were thin films of a pale to a deep blue coating, which had a somewhat glossy lustre.

The second consisted of putty-like lumps of a blue clay, which showed the impression of the fingers which had lifted it while soft; this clay contained imbedded fragments of lycopodia and mosses, with patches of a red-coloured substance.

The finer and purer bits of the first variety showed under a magnifier a fine fibrous structure, the fibres of which were transverse to the thickness of the veins,—they thus somewhat resemble crocidolite: the second somewhat resembled the earthy variety of Vivianite, though the structure was not loose enough or granular enough to make the resemblance complete.

The first of the localities to which I (in company with Mr. Horne) was conducted by Dr. Aitkin, was a road cutting in process of construction near Dochfour; this was being carried through the loose breccia. Both of the above varieties were to be seen here in abundance; and it was sufficiently evident that the second was merely an enlarged development of the first, in a less pure form.

Every rent—and the rock was pervaded with innumerable rents—was plugged with the mineral, from seams more delicate than tissue paper to vein-structure of over an inch in width.

Out of the larger veins the pulpy clay could be dug with the blade of a knife; and it was held in suspension as a blue cream in the ditches at the foot of the cutting.

The appearance and mode of occurrence were such as to induce a confident assertion that it was merely kaolin stained of a peculiar tint.

The breaking into the rock to a depth of little more than a foot, however enabled us to get rid of surface moisture, and sufficed to show the fallacy of the above opinion, for the mineral was then seen to fill the vein, not as a kaolinic powder, but as a solid, though much fissured schistose stone.

Fragments of this dry solid stone when placed suddenly in water, fell to pieces like bole, swelled up considerably, rapidly tinged the water blue, could almost immediately be worked up by the fingers into a slimy clay, and from which there could be separated a few unaltered fragments, both of quartz and of a red and gritty powder.

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A sufficiency of the substance in its *three* varieties was here collected.

So far from being inexplicable, there could not be anything more normal than the occurrence, in circumstances such as the above, of any mineral which was manifestly a product of decomposition.

There is to me at least something altogether inexplicable in the mode of occurrence of such a substance, at the second of the localities to which we were guided by Dr. Aitken.

This was the deep water-cut bed of the torrent called Dochfour Burn.

The smooth water-worn floor of this cañon-like gorge has been cut down to a depth of some 40 feet at its embouchure, and to a much greater depth a short way up its course. The gneiss of its bed has here suffered from no apparent change, for the rock is firm and unshattered, and the deep trench has exposed it, and is ever re-exposing it, so that only recent change can possibly affect it.

The gneiss itself shows here but little trace of the mineral; but in granitic veins which ramify throughout it in the very bed of the stream, and on the lip of a cascade, the mineral occurs in veins which are not the fillings up of opened shatterings, but which are firmly coherent, as are the other parts of the granite.

These granitic veins were broken into until our tools gave way. They were everywhere perfectly fresh and unchanged, the felspar bright and lustrous, and firmly coherent to the quartz: yet there, break it in what direction we pleased, was the blue mineral, occurring in veins from the thickness of an eighth of an inch to the thinnest of films.

The third locality at which Dr. Aitken and I observed the mineral was at the limestone quarry of Reelig. Here it filled thin fissures of the gneiss as at the first locality, and was also seen in a coarse crumbling granitic belt of the same rock.

In describing the mineral itself we have to note it in its three appearances.

First, as it occurs in thin veins with a transversely fibrous structure.

The material of these veins when they are exposed by the removal of one part of the rock which had enclosed them, is frequently seen to be in a singularly shattered condition, different portions of the little vein lying apart, and sometimes being adherent to the rock in an evidently false position. The fibres are somewhat paler in colour than is the surface formed by their terminations,—they have a high silky lustre. The colour is a pale blue to nearly white. They are easily crushed between the fingers.

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The schistose variety was very splintery, the cleavages or rents forming the splinters lay somewhat parallel to the sides of the vein which contained them. This variety was harder than the last and had a specific gravity of 3·326.

The last variety,—the "clay,"—was formed by the saturation of that just mentioned, by water. It was very soft, smeared the fingers and clothes on contact, and when stirred up with water went almost entirely into suspension.

Upon decanting the suspended particles from the impure sediment, the whole mass of liquid was seen to have a silky appearance, resembling, upon agitation, the twisted interwoven structure of mother-of-pearl, or *moire metallique*.

A drop examined by the microscope was seen to be filled with minute fractured fibres; so that this clay-like variety is nothing more than a coherent mass formed of the interlacing fibres of the first variety.

Being unable to obtain anything like a sufficiency of the fibrous mineral, my first analysis was made on the chips which I picked out of a vertical vein at Dochfour.

The specific gravity taken on a piece of 17·8 grains was 3·326.

The chips were cut down with the pliars to about the size of small shot, some little amount of red gritty matter being removed in the so doing. After purification as far as removal of all impurity visible to a lens, they were crushed in the diamond mortar, and pounded. During the pounding, however, red streaks appeared, and gritty matter was felt under the pestle; this was as far as possible removed, and after fusion with Fresenius flux, there was obtained from 1·001 gramme.

Silica	51·148
Ferric Oxide	14·921
Ferrous Oxide	9·803
Manganous Oxide	·299
Lime	1·118
Magnesia..	10·803
Potash	·63
Soda	6·518
Water	4·772
Sulphur	not det.
	100·012

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Of the above water ·948 were lost at 212°. As the red matter could not have been absolutely removed, this can be no more than a close approximation to the true composition,—the quantity of ferric oxide being doubtless too high.

B. B.—the mineral imparts to the flame a strong sodium reaction. With fluxes it gives the iron reactions. It fuses with difficulty into a blebby black glass, which is strongly magnetic. Its powder is insoluble in all acids.

The clay-like mass was picked as free as possible from all visible or tangible impurity under a lens; it was then rubbed up into a cream in a mortar with water, and the suspended portion decanted into a large jar of water. It was decanted several times from the heavier and coarser portions, and then set aside to subside from a large quantity of liquid. It settled with such extreme slowness that seven weeks elapsed before a sufficiency had subsided. This was obtained by the decantation of what was still in suspension, and drying the residue first in a water bath, and ultimately, when approaching dryness, in dry air. The colour of the material thus obtained was very fine and pure,—being like a pale ultramarine.

1· gramme of this sediment afforded—

		Atoms.	
Silica ..	52·4 ..	1·75	1·75
Ferric Oxide	9·339 ..	·117	·117
Ferrous Oxide	15·171 ..	·421	
Manganous Oxide	·4		
Lime.. ..	1·176 ..	·063	
Magnesia ..	10·5 ..	·521	1·581
Potash ..	·614 ..	·013	
Soda	7·106 ..	·229	
Water ..	2·968 ..	·33	
Sulphur ..	1· ..	·063	
	100·674		

Of the above water ·57 were lost at 212°. No alumina was found. As a check on this point the total iron was determined by potash precipitation,—by ammonia,—and by titration;

There was got

By Potash ..	26·25	Ferric Oxide
Ammonia ..	26·25	
Titration ..	26·1	

Sediment which has settled after four months suspension is hardly any finer in colour than what was examined; so that the sedimented clay

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may be regarded as being next in purity to the fibrous variety of the mineral.

Of the above analysis it may be said in the first place that there can be little doubt that the colour is due, as in ultramarine, to a ferruginous sulphuret of sodium.

The atomic ratios, as calculated out, hardly enable us to conjecture the true manner in which the ingredients are arranged; the atoms of the bases nearly balance those of the silica, so that probably it is a normal silicate.

It has been supposed that this substance was at one time utilised as a pigment in Inverness:—the ease with which it can be purified by washing, and decantation, and the delicacy of its colour—a kind of lively neutral tint—give very considerable countenance to this conjecture.

It will doubtless appear that, (while no more care and trouble has been taken in the determination of the nature of this substance than is called for in any and every case,) there has been much prolixity in the detail of the process employed for securing purity of material—as also of the modes of occurrence of the substance; the reason of this is *the absolute inability of the writer to account for its formation*, not to say for its almost universal distribution in the district in which it is found, and its entire absence from the same class of rocks beyond that district.

It did at first appear—from the open and decayed condition of the rock at Dochfour, and the occurrence of vegetable matter in its proximity,—as if it might be the product of an action of vegetable acids on the felspathic ingredient of the rock; but any such view must be absolutely set aside in presence of the following facts.

It was obtained by the writer from a portion of the rock at Dochfour, which, while it might have suffered from ordinary decay or alteration, was in no way exposed to the influence of the products of vegetable decay.

It is to be found in the interior of perfectly unaltered granitic veins, which are in no proximity whatever to vegetable matter.

The composition not only is not of the nature of kaolin, but from the absence of alumina is altogether different from it.

The composition in no way gives countenance to the view that the substance is the product of a change resulting from the action or influence of vegetable matter.

But the difficulty does not end here. While its occurrence in the shattered and changing rock at Dochfour,—the transverse arrangement of its fibres,—and the feeble grasp with which it holds together the fissured

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portions of the rock indicate, that it is at Dochfour and Reelig *a product of change*, its composition as such is very singular, for the rock does not visibly show the presence of any pyrites, or mineral capable of yielding the sulphur. While apparently (it must be borne in mind that the identity has not been proved by analysis) the same substance occurs in granitic veins in circumstances which give no countenance to our regarding it as *the product of a change of any kind.**

The attaining to any conception of the mode of formation of this Scottish ultramarine, is to the writer as difficult as was the attaining to the actual formation of true ultramarine to the chemists of a former generation, and probably can only be arrived at by an analysis of the unaltered, and also of the much altered rock-matrix.

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* The granite veins in the Dochfour Burn which carry the mineral show rarely minute specks of pyrite,—these are apparently quite unaltered; the mineral here is paler in colour than is usual.

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VII.—*Note on the modes of occurrence and localities of Abriachanite,*

By Thomas Aitkin, M.D. Inverness.

THE blue substance first came under my observation many years ago in one of the Slickensides, in the first quarry opened for the supply of Abriachan granite, and situated by the side of the road leading to Abriachan,—a somewhat isolated district amongst the hills overlooking Loch Ness.

It was then seen in purplish-blue spots, dotting here and there the surface of the rocks which had been exposed to considerable weathering, and over which water had poured freely.

Since then it has been found all along this ridge wherever the granite has been exposed, in patches of greater or less extent, on the surface, or in the cracks of the felspathic veins traversing the gneiss; —in many of the masses of rock fallen from the cliffs,—along the shores of the Loch,—and covering the gneissose blocks met with in considerable quantities in the Allt Cuig, a narrow burn immediately beyond the Loch-End Inn, a little more than six miles from Inverness.

Here it was first observed in what is its purest condition, in small rectangular looking masses of delicate and microscopic fibrous crystals of a bluish silky lustre.

It has also been found in narrow seams in the granite veins which force their way through the rocks of the Dochfour Burn, at the picturesque waterfall immediately above the bridge in the private road leading to Dochfour House.

Its greatest developement, however,—except at one station to be afterwards described,—is at a short distance east of the point last referred to, in an excavation made for metalling the road mentioned, at a spot where the rock is considerably shattered; this is possibly the result of a neighbouring fault, and the rock has been here much exposed to weathering and other disintegrating agencies.

At one period indeed during the summer, this road (formed by taking skillful advantage of one the numerous Kames forming so striking a feature at the mouth of the Great Glen,) presented, where the material

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was newly thrown down, a beautiful and brilliant blue color, which at once attracted attention.

At this point the mineral was noted in the crevices and cracks of the rock, or covering its surface in the form of a soft unctuous clay; in this, when examined microscopically, the beautiful and delicate parts already mentioned could be seen.

It has also been met with in numerous boulders apparently from the Abriachan district, scattered as far eastward as the Leachkin,—the face of the hill between Dunain and Craig Phadrick,—in the water-rolled pebbles and blocks in the gravel ridge running from Jorvain up to the foot of the Dunain Hill, and in one are two fragments of mica-schist picked from one of the stone heaps on the top of the Leachkin.

To the west of and behind Dunain extends a district known as Englishton Moor, and over this quantities of scattered boulders lie,—these contain the blue material in abundance.

After the development, however, mentioned by the side of the new approach to Dochfour House, it has been observed in largest quantities in the Reelig Burn. Here it is seen where the surface of the rock is exposed immediately below the mansion house of Reelig, and also lower down in masses of rocks which had perhaps fallen down during the preceding winter, into the bed of the burn, and not far from where some rude arches of stone-work exist.

The most striking aspect however which it has been seen to present was met with at the Limestone Quarry now being worked not far from the point last mentioned.

In one of the old workings on the surface of a large mass of rock which had recently fallen, the half was observed to be of a bright red colour from a coating of reddle or some similar substance, whilst the other half presented as seen in the bright sunlight, a dazzling blue appearance.

The district indicated in the foregoing description will be best understood by reference to Professor Geikie's or Professor Nicol's Geological Map of Scotland, and comprises roughly an extent included within a line drawn from the middle of the granite region on the north western shore of Loch Ness, to the burn shown as finding its way into the Beauty Firth at Kirkhill. It must not however be understood that the mineral may not be found beyond this area, but investigation has not extended beyond this in a westerly direction; and it was not picked up in Glen Urquhart during last summer in frequent excursions made to this part of the country.

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The mineral itself is *apparently* connected with the disintegration and decomposition of the felspar contained in the various rocks of this district. It occurs as already remarked in various forms; covering the surface of the rocks in which it is found with a fibrous bluish-white silky-like coating, or a bluish-white powder, or in seams of a more or less dark-blue tint.

It has also been met with of a whitish-blue colour, generally diffused through fragments of gneissose rock, picked up in the Allt Cuig Burn; and lastly it has been obtained in what is believed to be its purest form, in the minute rectangular masses composed of delicate microscopic fibres of a silky lustre, and of a bluish colour.

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VIII.—*On Haughtonite; a new Mica.*

By Professor Heddle.

DR. HAUGHTON, by his numerous analyses of the black micas of the Irish granites, may be said to have established the specific individuality of the *lepidomelane* of Hausmann.

That mineral his analyses showed to differ from Biotite in its great excess of ferric oxide and its comparative deficiency of ferrous oxide and magnesia.

The oxygen-ratios of Irish lepidomelanes as compared with Scotch Biotites are as follows:—

	Lepidomelane.	Biotite.
Silica	20 ..	21
Peroxides	15·5 ..	8
Protoxides and water ..	7 ..	15

there being thus an inversion of the relative proportions of the bases.

Lepidomelane is somewhat heavier and somewhat harder than Biotite;—in other properties the minerals are similar.

I had occasion some years ago to observe that the black-scale mica of the Scotch granites and granitic dykes and rock-belts, contained much the largest proportion of its iron in the *ferrous* condition,—thus differing from lepidomelane; and that they contained very little magnesia, and thus differed from Biotite.

I also found that while in Scotland Biotite was confined to limestone and serpentinous rocks, *this* black-scale mica was never found therein, but was confined to the rock matrices I have above named.

A sufficiency of analyses have shown this Scotch mica to be altogether distinct; and I propose to name it after Dr. Haughton, whose work among the micas and granites in every way entitles him to honourable recognition.

Physically this new mica is somewhat heavier and somewhat harder than lepidomelane, and its characters as a whole give it a position which places lepidomelane as an intermediate between it and Biotite.

In submitting the analyses I have made of this mineral, I arrange them in geologic sequence, commencing with the deeper-seated rocks, and rising in succession to the more recent.

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Occurrences in hornblendic (Laurentian) gneiss.

The mineral may occur in the general mass, or in the felspathic bands of this rock, but I have not yet got it in quantity sufficient for analysis. I have though obtained it in the former, in specimens sufficiently characteristic for recognition.

In the granitic veins which cut the rock it occurs in much the finest specimens that I have seen.

In the southern part of Harris a number of huge dykes cut the gneissic beds, generally at right angles.

A great dyke of this description is to be seen on the north-east side of the hill of Roneval; it is glaciated so as to be polished as well as rounded. It is so dense and solid that our heaviest hammers could not find a weak joint to attack; but my friend Mr. Dudgeon and I measured many edges of worn-down crystals of this black mica, which were over a foot in length. We had to content ourselves, however, with merely a quantity of chips sufficient for analysis;—this was, from the same cause, also the case with the magnetite which accompanied it. Only blasting tools could here effect more.

The mineral is here jet-black, transmitting light of a dark brown tint when in very thin plates. It is slightly biaxial, very tough, and so is powdered with great difficulty; the powder is black with a slight shade of green. Its specific gravity is 3·03.

Its analysis yielded—

Silica	37·164
Alumina	15·006
Ferric Oxide	7·689
Ferrous Oxide	17·353
Manganous Oxide	1·044
Lime	1·128
Magnesia	8·88
Potash	8·18
Soda	1·605
Water	2·121
	100·160

About two thirds of the water is lost at 212°, the rest is retained with extreme tenacity.

2. There is an enormous dyke which cuts through the east foot of the hill of Capval, in the south west of the same island. This dyke contains many substances, but this one only in small quantity, and in a mode of arrangement different from that of the Roneval mineral.

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At Roneval the crystals were isolated and lay in almost every direction; at Capval they were in divergent groups of elongated crystals. The colour was jet black, they were slightly biaxial. Their specific gravity was 3·071.

They yielded—

Silica	36·806
Alumina	15·22
Ferric Oxide	7·611
Ferrous Oxide	17·353
Manganous Oxide	·96
Lime	1·54
Magnesia	8·784
Potash	8·31
Soda	1·342
Water	2·47
	100·396

3. Further north on the west coast of the same island, at a point intermediate between Nishibost and Borve, there is a mass of fine-grained granite of such dimensions that I could not ascertain whether or not it was to be regarded as a vein. This granite is itself riddled with exfiltration veins, and in these the mineral is found in crystalline plates of a most brilliant lustre and a colour of pitchy blackness. Occasionally here, however, the edges of the plates are coated with a bright-red rust. They are biaxial to the extent of 2° or 3°, and their specific gravity is 3·05.

They yielded—

Silica	35·154
Alumina	16·704
Ferric Oxide	5·961
Ferrous Oxide	19·063
Manganous Oxide	1·016
Lime	·818
Magnesia	7·461
Potash	9·243
Soda	1·259
Water	3·133
	99·812

4. Still further north on the west coast of the same island, but now in the portion of it called Lewis, the same mineral occurs. The locality from which we took the specimens was the north shore of a small fresh-

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water lake called Loch-na-Muilne, which is situated near the north shore of Loch Roag.

The specimens were again in granite veins, but here oligoclase was along with orthoclase an associate. The colour was dark-brown to black.

Analysis gave—

Silica	36·461
Alumina	17·253
Ferric Oxide	4·18
Ferrous Oxide	15·325
Manganous Oxide	·538
Lime	·689
Magnesia	12·23
Potash	9·204
Soda	·657
Water	3·385
	99·922

Of the water ·325 was lost at 212°.

5. Crossing to the mainland of Scotland, we find the same mineral in the same rock, and in the same association.

It may be said to be everywhere seen in the granitic veins, though it does not always occur in quantity sufficient for analysis, or even for the obtaining characteristic specimens.

The western slope of the great hill of Fionaven in Sutherland carries, at a height of 750 feet, a number of large veins. These are for the most part made up of orthoclase and oligoclase. Haughtonite is here very rare, but it is in the most lustrous and jetty-black plates that I have seen. The plates seemed here to be hexagonal.

Their specific gravity is 3·032.

They yielded—

Silica	36·75
Alumina	17·858
Ferric Oxide	2·781
Ferrous Oxide	15·175
Manganous Oxide	·416
Lime	·933
Magnesia	11·166
Potash	9·437
Soda	1·247
Water	4.232
	99·995

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Of the above water ·967 was lost at 212°.

6. From a fallen mass of a granitic nature which lay near the south shore of Loch Stack, in the same county, I got larger plates of the mineral. The mass was angular and fresh, and probably had formed part of a vein in the overshadowing precipice of Ben Stack.

The mineral here was of a brown-black colour—not so lustrous as elsewhere. Its powder was somewhat greenish, its specific gravity was 3·05.

Its analysis gave

Silica	35·692
Alumina	20·086
Ferric Oxide	2·233
Ferrous Oxide	14·011
Manganous Oxide	1·
Lime	1·895
Magnesia	14·769
Potash	7·381
Soda	·529
Water	2·465
	100·061

7. A tortuous and nodular vein of red graphic-granite is imbedded in the gneiss on the north side of the little harbour of Rispond, on the west shore of Loch Erribol. Magnetite, oligoclase, and Haughtonite occur in this.

The Haughtonite is here present in small jet-black plates of a high lustre; and in large brownish ones of less lustre.

The black was analysed; its specific is 2·99.

It gave

Silica	36·538
Alumina	22·282
Ferric Oxide	2·433
Ferrous Oxide	16·009
Manganous Oxide	·784
Lime	1·249
Magnesia	10·
Potash	8·264
Soda	·794
Water	1·506
	99·856

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From the Felspathic Belts of Micaceous Gneiss.

8. In the rocky face of the rounded hill called Clach-an-Eoin between the mouths of the Navir and the Borgie in Sutherland, the micaceous gneiss contains this mineral in somewhat large plates, though not in large amount. The worn edges of the crystals present themselves, and though the mineral is on its cleavage planes brown, these edges have a blue tint, and bear a singular resemblance to tarnished metallic lead. The associates here are garnet, rutile in crystals, ilmenite and chlorite —all are imbedded in quartz.

The plates of mica are clove-brown in colour, and reddish-brown by transmitted light. They are slightly biaxial.

Their specific gravity is 2·96.

They yielded—

Silica	35·846
Alumina	21·539
Ferric Oxide	4·467
Ferrous Oxide	18·306
Manganous Oxide	·307
Lime	1·249
Magnesia	8·076
Potash	7·759
Soda	·794
Water	1·956
	100·299

From intrusive veins in Micaceous Gneiss.

9. A vein of pale lavendar almost white microcline cuts the gneissic or greywacke schists with a semicircular sweep, immediately to the north of the lighthouse at Kinnaird's Head in Aberdeenshire.

This contains the mineral in very dark crystals, which, when split thin, have a fine rich dark-green colour. A small quantity of radiated Cleavelandite is also imbedded in the microcline.

The Haughtonite here is brittle, and pounds with unusual facility. It is hardly perceptibly biaxial. Its specific gravity is 3·126.

Its analysis gave—

Silica	35·666
Alumina	17·947
Ferric Oxide	7·191
Ferrous Oxide	18·063
Manganous Oxide	2·
Lime	1·4
Magnesia	1·5
Potash	9·273
Soda	3·81
Water	3·2
	100·050

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This differs from all the others not only in its colour, but in the small quantity of magnesia which is present.

The locality was discovered by a former pupil, Mr. James Wilson of the Geological Survey.

From Intrusive Veins in Granite.

10. In the granite quarry of Cove, five miles south of Aberdeen, the veins carry the mineral in a peculiar association with Muscovite. Elongated crystals of the Haughtonite lie imbedded in crystals of Muscovite parallel to their larger diagonal.

It requires some force to tear the plates of the one mica separate from the other. This close consorting is singular, as the two are seldom even associated in the same rock or locality.

The colour here is brown. It is uniaxial.

Analysis gave—

Silica	35·469
Alumina	18·798
Ferric Oxide	4·611
Ferrous Oxide	19·188
Manganous Oxide	·643
Lime	·904
Magnesia	7·007
Potash	8·188
Soda	·238
Water	4·97
	100·016

From exfiltration veins in Syenitic Granite.

11. The fine-grained granite which forms the little hill of Cnoc-dubh about a mile east of Lairg in Sutherland, carries in its mass small crystals of sphene and hornblende.

A vein of a foot or two in width traverses it on its north side, and from this quite an assemblage of minerals were got.

Orthoclase, oligoclase, sphene, allanite, and this mineral, in long, narrow, pale-green crystals with a somewhat greasy lustre, and a slight appearance of decomposition all occur here. Those which were deep-seated were of the usual brown colour.

The plates here were so twisted that none sufficiently large for ascertaining either the optical properties or the specific gravity could be found.

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The analysis gave—

Silica	35·555
Alumina	16·694
Ferric Oxide	1·883
Ferrous Oxide	18·037
Manganous Oxide	·694
Lime	2·722
Magnesia	8·472
Potash	9·896
Soda	·105
Water	5·714
	99·722

From Diorite.

12. There is a good deal of a dark mica throughout the dioritic rocks of Banffshire in certain localities.

This mica would appear to replace the hornblende, for in some parts of the county, as near Rhynie, the rock contains only labradorite and the mica.

Only at one spot, however, have I succeeded in getting a sufficiently large mass for analysis, so I am unable to say that all the dark mica of this rock is of the same nature; it has in many places, especially in the veins, very much the appearance of Biotite.

The locality where the mass was obtained was the west shore of the bay of the Durn near Portsoy, where by a chance-find, a portion of a vein some pounds in weight was got.

It consisted of a mass of crystals twisted into one another in most confused arrangement; the colour was a somewhat bronzy-brown; the lustre greasy and glimmering, the specific gravity 3·074.

The composition is—

Silica	34·076
Alumina	17·339
Ferric Oxide	3·613
Ferrous Oxide	18·703
Manganous Oxide	·384
Lime	3·23
Magnesia	10·538
Potash	6·78
Soda	1·193
Water	4·052
	99·908

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I have also analysed specimens of doubtless the same mineral from near Cape Wrath and from the Clova Hills in Aberdeenshire; but the specimens from the former locality had apparently suffered peroxidation, while those from the latter were possibly contaminated with the gneissic matrix.

Twelve fairly closely accordant analyses from seven diverse geognostic habitats are, however, amply sufficient for estimating the claims of any substance to be considered entitled to specific distinction.

The following table presents the general accordance in composition to the eye.

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	Sp. G.	$\ddot{Si}$.	$\dddot{Al}_2$.	$\dddot{Fe}_2$.	$\dot{Fe}$.	$\dot{Mn}$.	$\dot{Ca}$.	$\dot{Mg}$.	$\dot{K}_2$.	$\ddot{Na}_2$.	$\dot{H}_2$.	Total.
Roneval	3·03	37·16	15·	7·69	17·35	1·04	1·3	8·88	8·18	1·6	2·12	100·17
Capval	3·07	36·81	15·22	7·61	17·35	·96	1·54	8·78	8 31	1·34	2·47	100·40
Nishibost	3·05	35·15	16 7	5·96	19·06	1·02	·82	7·46	9·24	1·26	3·13	99 81
Loch-na Muilne ...		36·46	17·25	4·18	15·33	·54	·69	12·23	9·2	·66	3·39	99·92
Foinaven	3·03	36·75	7·86	2·78	15·18	·42	·93	11·17	9·44	1·25	4·23	99·99
Ben Stack	3·05	35·69	20·09	2·23	14·01	1·	1 89	14·77	7·38	·53	2 47	100·06
Rispond	2·99	36·54	22·28	2·43	16·01	·78	1·25	10·	8·26	·79	1·51	99·80
Clach-an-Eoin ...	2·96	35·85	21·54	4·48	18·31	·81	1·25	8·08	7·76	·79	1·96	100·33
Kinnaird's Head ...	3·13	35·67	17·95	7·19	18·06	2·	1·4	1·5	9·27	3·81	3·2	100·05
Cove...		35·47	18·8	4·61	19·19	·64	·9	7·01	8·19	·24	4·97	100·02
Lairg		35·56	16·69	1·88	18·04	·69	2·72	8·47	9·9	·11	5·71	99·77
Portsoy	3·07	34·08	17·34	3·61	18·70	·38	3·23	10·54	6·78	1·19	4·05	99·9
Average	3·04	35·93	18·06	4·55	18·06	·81	1·49	9·07	8 49	1·12	3·27	

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The averages of the twelve, and the oxygen ratios are as follows:—

		Oxygen.		
Silica	35·93	19·16	19·16	19
Alumina ..	18·06	8·41	9·78	10
Ferric Oxide	4·55	1·37		
Ferrous Oxide	18·06	3·8	12·67	12·5
Manganous Oxide	·81	·18		
Lime	1·49	·42		
Magnesia ..	9·07	3·63		
Potash	8·49	1·44		
Soda	1·12	·29		
Water	3·27	2·91		

These ratios are so different from those of lepidomelane and of Biotite, as to leave no room for doubt that the mineral is quite distinct from either.

But the question is,—is it new? It is new as regards its specific individuality being now for the first time indicated, but not new as regards its being now for the first time analysed. From Dana's table of analyses of Biotite I select three, to which I have added two from a more recent source.

	$\dot{Si}$	$\dot{Al}_2$	$\dot{Fe}_2$	$\dot{Fe}$	$\dot{Mn}$.	$\dot{Ca}$	$\dot{Mg}$.	$\dot{K}_2$	$\dot{Na}_2$	$\dot{H}_2$	Total.
16. Brand	37·18	17·53	6·20	15·35	·31	·79	9·05	5·14	2·93	3·62	98·1
17. Do.	37·06	16·78	6·07	15·37	tr.	·57	9·02	5·96	2·86	3·77	97·46
18. Hartzburg ...	36·17	18·09	8·7	13·72	...	·52	11·16	7·59	tr.	2·28	98·23
Schwarzwalder...	33·6	15·	4·99	19·29	...	3·36	11·62	7·53	·51	4·58	100·48
Tydrberger ...	35·5	18·01	9·24	12·11	tr.	3·02	10·86	9·18	1·93		99·85

The averages of these and their ratios are—

		Oxygen.		
Silica	35·9	19·1	19·1	19
Alumina.. ..	17·08	7·96	10·07	10
Ferric Oxide ..	7·04	2·11		
Ferrous Oxide	15·17	3·36	12·34	12 5
Lime	1·65	·47		
Magnesia ..	10·34	4·14		
Potash	7 08	1·2		
Soda	1·64	·42		
Water	2·85	2·75		

Being the same as the Scotch mineral, and standing forward as unimpeachable evidence of its distinctiveness.

In its atomic ratios the mineral stands intermediate between Biotite and lepidomelane, but that which really constitutes the distinctive features of these three micas is the state of oxidation of the iron.

In Biotite the relative proportion of ferrous to ferric oxide is about as 25 to 1.

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In Haughtonite (Scotch) it is as 4 to 1.

In Lepidomelane it is as 1 to 9.

There are the following additional chemical distinctions:—

Biotite differs from Haughtonite in containing an amount of magnesia which is twice as great as that of the ferrous oxide; while in Haughtonite the relative proportions of the above protoxides are more than inverted. In the last mineral the iron is chiefly in the ferrous state, in lepidomelane it is chiefly in the ferric.

Altogether there can be no doubt that the mineral is a new one, and I conceive that it is most fitting that it should be named after the gentleman who first analysed the black micas of Ireland, and so established firmly the claim of lepidomelane to be considered a distinct mineral.

It is also happily fitting that it should be called after Dr. Haughton, seeing that it is in Scotland the distinctive mineral of the grey granite, a variety of that rock in the study of which Dr. Haughton has been for long engaged.

The geognostic relations of this mineral are well marked.

In Scotland Biotite occurs in limestones and serpentines, and never in granite.

Haughtonite is never found in the two former rocks, and affects granite more than any other.

We find it chiefly, however, in granitic veins, especially in exfiltration veins. It is the mica special to the mass of that grey granite which covers so large a tract of the county of Aberdeen; muscovite is hardly to be seen in this granite. And the veins of this granite almost invariably show the dark mica in large crystals.

It also occurs in the felspathic bands of gneiss, especially in the highly metamorphosed gneisses.

It is a fact, the bearing of which I have not yet attained to, that oligoclase is its almost invariable associate, and sphene and allanite also frequently accompany it.

I have never yet seen it in distinct crystals, but it has an orthorhombic habit. It frequently occurs in long tortuous crystals—an appearance which I have never seen either Biotite or lepidomelane assume.

Before the blowpipe it fuses with difficulty to a strongly magnetic bead;—the plates of the mineral assume a black of great intensity; Biotite and lepidomelane both pale in colour when heated.

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It is more difficultly decomposed by acids than either Biotite or lepidomelane. Chlorhydric acid does not thoroughly effect its decomposition; it gives way to sulphuric however, the silica being left in scales which retain the original lustre of the mineral, or have even acquired a still greater brilliancy.

It does not resist the decomposing power of the atmosphere, as muscovite does; the large amount of ferrous oxide becomes an element of weakness; and some granites crumble from the changes so entailed.

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III.—*On some Gold Occurrences.*

By the Rev. J. Clifton Ward, F.G.S., F.R.M.S.

SOME time since Prof. Ruskin kindly sent me a specimen of gold-quartz brought from New Zealand by Mr. H. A. Severn, giving me leave to cut thin slices for the microscope, and asking me to examine the same. The result seems to me of some interest, and Mr. Ruskin has kindly consented to my bringing it before the Mineralogical Society, together with a notice of a strangely beautiful gold occurrence, described by Mr. Severn as disclosed by blasting in one of the New Zealand gold reefs.

Moss-form Gold in Quartz.

The specimen first to be described came from the "Wham Mine," Thames District, Auckland, N. Z. Mr. Severn says "the gold here is largely alloyed with silver, *the two always running together*. The percentage of silver is about 32, the price paid for the gold varying from £2 to £3 per oz. The reefs in some of the mines present remarkable features, bands or layers of auriferous quartz being found of *great value*; thus, in one case 26,000 ozs. were taken out in a few days. Usually both above and below the quartz seam are parallel layers of Antimony and Mundic, the presence of these being always considered a good omen."

The sample of gold-quartz sent me by Prof. Ruskin, was rather more than 2 inches long by 1½ inches to 1¾ inches across. Externally there was nothing to indicate the structure disclosed by slicing. The gold appeared finely disseminated in minute points and grains, giving a yellowish tinge to the richer portions.

Several thick slices (⅛ in.) were cut, and two very thin ones for microscopic examination. All these revealed a beautiful moss-like crystallization, but feebly represented in Fig. 1 Plate 1. The gold appeared in numerous fine lines at all angles with one another, and seldom more than the ⅛th of an inch in length, surrounded by shorter gold lines and fine dust, the whole presenting somewhat of a moss-like appearance. Some of the lines were thicker than others, and evidently

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represented a more oblique section of the fine gold plates or laminæ of which the finest lines were the transverse sections. In some cases indeed the gold laminæ lay in the plane of the section, but seemed in no instances to be bounded by definite lines, rather to be minutely *fringed* out.

The moss-like growth ended in an irregularly rounded outline, tree or rather shrub-like in form, and the quartz above presented a milky appearance (in the $\frac{1}{8}$ in. slices), and was entirely free from gold in any form (see fig. 1). More recent quartz strings seem to have intersected the mass and they also were free from gold.

The thin slices viewed under the microscope gave no further information with regard to the gold, no distinct crystalline forms being observable.

The quartz was carefully examined for liquid cavities, but whereas the quartz of most quartz veins abounds in them, and they may be readily seen with a good $\frac{1}{2}$-in. or $\frac{1}{4}$-in objective, no single definite liquid cavity was discovered with a magnifying power of 660 diameters. The quartz is much traversed by fine cracks, and under polarized light presents the usual coloured mosaic representing separate crystalline portions. Minute semi-transparent granules are scattered about, and one instance was noticed of a slender transparent needle shooting out from a line of crack. There was nothing special to distinguish the quartz forming the secondary veins from that of the mass.

Tree-form Gold in Quartz Cavern.

The occurrence now to be mentioned was brought to my notice by Mr. Ruskin, and the following particulars are derived from Mr. H. A. Severn. The latter says,—"In the Caledonian Mine, (New Zealand), the gold found amounted to some 12 tons in as many months. A very beautiful specimen was disclosed by a blast; a small cavern was thus brought into view, the interior of which was covered with crystals, but from the centre of its floor grew a golden tree, the lovely and intricate golden branches spreading in all directions, its roots as if growing into the quartz. More singular still were many buds, like pin heads, attached here and there to the golden branches, and these on examination proved to be mundic crystals!"

From further inquiries, I learn from Mr. Ruskin, who saw some of the tree-like gold, that it "was just entangled enough to support itself, and no more, trembling with a breath, and not visibly crystalline anywhere to the naked eye." From a pen and ink drawing given me in a letter from Mr. Ruskin, Fig. 2 Plate 1 is taken, to show the shaky

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character of the gold thread-stems. Mr. Severn further writes that some of the threads were flat and bent over, that there was no earthy matter whatever in the small cavern, and that the mundic crystals at the ends of the golden threads were *perfect, of decided form, and belonging to the rhombic system.* Gold specks were disseminated in the rock beneath the cavern floor.

I leave the occurrences above-mentioned to the notice of mineralogists. That they are of interest in connection with the origin of gold can hardly be questioned. The laminar gold occurring in Moss-like form, embedded in quartz, free from liquid cavities (unless excessively minute), suggests whether the silica and associated gold could have been deposited in this case by hydro-thermal agency, the water playing a chief part? for if so, how does it happen that the quartz in the immediate neighbourhood of the gold does not show liquid cavities of the same degree of development as in most quartz-*veins?* Is it a usual or *unusual* thing, I would ask, for liquid-cavity bearing quartz to be in juxta-position with gold? Possibly this question yet requires working out, and had I the material to hand I would gladly do my quota towards the investigation.

Although the moss-form gold occurrence may be considered only doubtfully to support the theory of a watery deposition, yet the tree form occurrence seems hardly explicable on any supposition but that of crystallization from an aqueous solution. Its mode of growth within a small cavern or geode, the quartz crystals pointing inwards from all sides of the cavern, and even the gold disseminated in the floor, all seem to point to gold dissolved out of the surrounding rocks or carried up in solution from below, and then slowly crystallizing out from the solution within the cavern. It is impossible to conceive of the hollow being filled with igneously fluid matter from which the gold separated, the igneous mother-liquor wholly disappearing; and very difficult to imagine how the tree could be shot up from the floor of a *dry* cavern, or why it should so grow. On the other hand, on the aqueous theory of deposition, one might suppose that the pyrites heads at the end of the golden fibres represented the last metallic matter contained in solution, the last traces of gold being deposited with the pyrites.

There is so much to support the theory of an igneous deposition of gold (see especially Belt's views in this matter, in his "Nicaragua," pp. 99-102) that the meeting with an occurrence of the tree-form character described, is of special interest. Most likely, the precious metal owes its mode of occurrence to deposition under varied conditions, at one time igneous (fire the chief element), at another hydro-

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thermal (water being the conspicuous element). So persistently does nature refuse sometimes to be limited to one hypothetically perfect method of action.

I have brought this matter before the Society with some misgiving, thinking that possibly after all, phenomena such as those described, are well known to mineralogists, though I have failed to meet with them described in books, or coming within the experience of many friends of whom I have made enquiry. I trust others may be induced to develope the subject, and follow it into regions beyond my reach.

Postscript.—Since writing the above, my friend Mr. Rutley has shown me a beautiful case (almost unique I believe) of gold upon selenite. Surely this must mean aqueous deposition. Mr. Ruskin has also shown me his beautiful collection of gold occurrences, which might well have a special memoir devoted to them.

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IV.—*Additional Note on Penwithite.*

By J. H. Collins, F.G.S.

SINCE my former communication to the Mineralogical Society* I have been endeavouring to obtain a sufficient quantity of the pure mineral therein described to complete my analyses. Plenty of what certain dealers have been selling as Penwithite is obtainable from the rubbish heaps at Wheal Owles, but this is mostly dark-brown—nearly or quite opaque, pitch-like in appearance, and of very variable composition—the silica alone varying from 22 up to 57 p. c., and the sp. gr. often being as high as 3·4.

The true mineral is sometimes attached to masses of such material—it is highly vitreous and transparent, from dark amber to reddish-brown in colour, H. 3·5 and *sp. gr. only* 2·49—a remarkable circumstance considering the large amount of manganous oxide present. Its other properties are as stated in my former note; for convenience I reproduce the particulars here. It is brittle, has a highly conchoidal fracture; heated in matrass gives off water, but is otherwise unchanged; strongly heated in platinum forceps fuses slightly on edges; when digested in coarse powder in hydrochloric acid oxide of manganese is dissolved out and the silica which remains is perfectly colourless.

The mean of three more or less complete and fairly concordant analyses, each, however, performed on less than ½ a gram of the mineral, is as follows:—

Water	21·80 p. c.
Silica	36·40
Oxide of manganese	37·62
Manganic anhydride	tr. †
Oxide of iron	2·52
Uranium peroxide	·30
Copper	tr.
	98·64

Reckoning the iron and uranium as manganese, this answers very closely to the formula $Mn\,Si\,O_3 + 2\,H_2O$, which requires the following proportions:—

MnO	42·5
SiO_2	35·9
H_2O	21·5
	99·9

* Min. Mag., Vol. II, p. 91.

† The powdered mineral when warmed with solution of potash communicates a green tinge from the formation of manganate.

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The chemical composition of this mineral places it near Dana's Neotokite (var. Wittingite)* from Bredvik, which was analysed by Nordenskjold, but the manganese in this latter is in the form of sesquioxide, while in Penwithite it is a protoxide. Moreover, the physical properties are greatly different.

Neotokite is said to be formed by the alteration of Rhodonite, but this does not appear to be the case with Penwithite. On the contrary, it is in some specimens accompanied by entirely unaltered Rhodocrosite, a mineral much more readily altered than Rhodonite: it seems to have been formed like opal by the deposition of a gelatinous siliceous solution in cavities of pre-existing rocks, and several varieties of opal have in fact been found at Wheal Owles, some of them slightly tinged with manganese oxide.

* Dana, Syst. Min., 1875, p. 491 anal 8.

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V.—*Note on Christophite from St. Agnes.*

By J. H. Collins, F.G.S.

ABOUT a year since I received from our associate Mr. Alfred Davies, of St. Agnes, a dark-brown mineral which was supposed to consist largely of sulphide of tin. As it differed greatly in appearance from the so-called tin pyrites, I at once felt interested in the supposed new mineral, and commenced an analysis which I have lately been able to complete.

It is generally granular in appearance, dark-brown, translucent very slightly on thin edges, infusible B.B., soluble more or less completely in aqua regia, &c.—in fact its properties differ but little from those of an ordinary dark variety of blende, except that with careful manipulation it yields a bead of tin when treated with reducing agents on charcoal. Most specimens are massive, dark-brown and granular as stated above, but certain small cavities are usually studded with black lustrous crystals, generally minute, but occasionally about 1-3rd of an inch across. The best of these crystals which I have seen exhibits planes of the hemihedral cube and of the positive and negative tetrahedrons.

The mean of several analyses of the granular mineral is as follows:—

Zinc	32·0 per cent.
Iron	22·4 ,,
Tin	1·2 ,,
Sulphur	29·5 ,,
Alumina	7·2 ,,
Silica	6·8 ,,
Copper	trace.
Lime	trace.
	99·1

No alumina or silica can be detected in the crystals by blowpipe tests, but I have not been able to obtain enough of them for a complete analysis. Still there can be no doubt that they are extraneous bodies, and form no part of the mineral as such. Eliminating these constituents we have the following as the probable composition of the mineral:—

Zinc	37·6	Zn S.	56·1
Iron	26·2	Fe S.	41·1
Tin	1·4 =	Sn S.	1·9
Sulphur	34·7	S.	·8
	99·9		99·9

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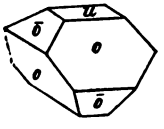
The tin I think does really form part of the mineral, and probably exists in the state of sulphide, as it is readily soluble in aqua regia, which solvent scarcely attacks native peroxide of tin in the slightest degree. The mineral is therefore very near that variety of blende named *Christophite** by *Breithaupt* from its occurrence at St. Christophe Mine near Johanngeorgenstadt—differing from it only in the larger proportions of sulphide of iron (which is to the sulphide of zinc nearly as 6:5 in molecules) and of tin.



My friend Dr. C. O. Trechmann, of Hartlepool, to whom I shewed the crystals referred to above and figured here, thus describes them :—"The Blende is a very interesting though by no means an unusual development. The crystals are simple (*i.e.* untwinned) and show the usual combination of the two tetrahedrons with the cube; the large development of the 2nd tetrahedron is rather uncommon, and causes the whole crystal to approximate to a holohedral habit. That it is not holohedral is shown by the superficial character of the tetrahedral faces, those belonging to the first, probably the + tetrahedron, are large, bright (polished) and striated parallel to the edges formed by the cubical and 2nd tetrahedral faces, whilst the 2nd, probably the − tetrahedron is small, dull, and uniformly rough. The cube is striated parallel to the 1st tetrahedron.

A slight fracture has exposed the dodecahedral cleavage on the large crystal.

These crystals from St. Agnes are very similar to the beautiful crystals of the same combination from the Binnenthal (dolomite) in Switzerland; though in the latter the striations of the cubical faces generally run in the opposite directions."

* Dana, System of Mineralogy, 1875, p. 49, anal. 14.

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The "Maxwell-Stuart" Topaz.

Natural Size.

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The "Maxwell-Stuart" Topaz.

FIG. 1.

FIG. 2.

Fig. 1. Front view. Natural size.
Weight, 1475·9 Grains or 368 Carats 3 9/10 Grains.
Colour, Pure White.
Specific Gravity, 3·5685.
Locality, Ceylon.
Fig. 2. Side view. Natural size.
now in the possession of Mr Bryce Wright.

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IX.—*The History of a Remarkable Gem.—The "Maxwell-Stuart" Topaz.*

By J. H. Collins, F.G.S.

IT is only within the last century that the Cingalese have become the most astute judges upon all matters relating to gems in their uncut or natural state. That this is so is proved by the number of remarkable stones which previously found their way to England, unrecognized as being of any value; amongst them is the stone in question. How it could have been passed over and treated by the merchants as of no value is a mystery, unless its great size contradicted the probability of its being a gem. Such, however, was the case; it having been sent to England mixed with the ordinary pieces of inferior Rubies and Sapphires used by watchmakers. It was sold for a mere nominal sum, as a piece of Quartz, or Crystal, and passed into a private collection of minerals, the owner of which regarded it also as a specimen of Quartz. At his decease it was sold by public auction with his minerals, by Messrs. Stevens, the natural history auctioneers, of Covent Garden. Again, remarkable to relate, not any of the mineralogists or dealers in gems recognized it, and it was purchased with other stones by a private gentleman, Mr. Herbert Maxwell-Stuart, of Scarthingwell Hall, Yorkshire, for the sum of £3 10s.

This gentleman, having collected gems for many years, and being an authority on uncut gems, immediately discovered its true nature, and for many years it formed the centre of attraction in his cabinet, and was shown to the gentry of the county as being the largest gem in the world. At last Mr. Maxwell Stuart decided to have it cut and polished, and travelled from York to Edinburgh, to consult the lapidaries there on the subject. However, a great disappointment awaited him. He was informed, after examination, that it would be impossible to cut such a large stone (measuring about 4½ inches square) of that material, its hardness being so great. It was also stated that even if cut, it would not be pure, two or three large flaws to all appearances running nearly through the stone. Some London lapidaries said the same, and the gem lay for some time untouched, until Mr. Maxwell-Stuart showed it to Mr. Bryce-Wright, of Great Russell Street, London, who, upon examination, not only pronounced the cutting perfectly feasible, but believed it could be accomplished without leaving a single flaw. He further offered to purchase it for a large sum if he was satisfied on re-examining it with the aid of a powerful artificial light. This was allowed

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and Mr. Maxwell-Stuart, perhaps doubting the feasibility of its being cut, and especially without a flaw, was tempted to part with the stone.

On securing the gem, Mr. Bryce-Wright had several moulds taken of it, from which were cast in gelatine eight or ten perfect models upon which to operate. The gem itself was then examined with the greatest care under a lime-light, being previously dipped in a preparation of turpentine to render it more transparent, and the exact position, width and length of the flaws carefully noted. These were then measured and imitations of them made *in wood* of the precise length and width; they were then inserted in the models of gelatine in exactly the same positions as the flaws were in the original. Thus several imitations of the real gem were made, containing pieces of wood in place of the flaws. These were then cut out of the gelatine in several directions, care being taken to cut perfectly straight, or in a manner that a lapidary's wheel could act, leaving several irregular blocks of gelatine representing the gem *without* the flaws. It was then easy to choose the form of cutting, and to determine upon which model the true gem was to be cut.

The stone was then placed upon the wheel and cut precisely to the shape of the chosen model, thus effacing all the flaws. Here victory seemed complete, as the polishing was all that had to be done, when unfortunately, what is termed a feather appeared, perhaps through the strain in cutting, in the position in which it was determined to place the table. This seemed at first sight an insurmountable difficulty, until Mr. William Lunan, the lapidary employed proposed to remove the "feather" by reversing the original plan, and placing the table where it had been arranged the culet should be. The feather which was horizontal was thus removed in the cutting and polishing of the large plane. The gem was cut as a brilliant on a diamond wheel, without further mishap. The polishing was the next step, the wheel for this purpose was of an unusual size, and made of bell-metal. The rapidity with which this had to be driven to polish such large facets on such a hard stone was very great, and rendered it impossible to continue the work for more than a minute or so at a time; the stone being so hot, as also the cement forming the handle to which it was attached, that it could not be held in the hand.

Plate III is an outline shewing the original size of the gem with the positions of the principal flaws. The final result of the cutting is seen in figs. 1 and 2, plate IV.

The operations of cutting and polishing commenced on the 12th May, ended on the 12th June, having thus occupied 28 days of incessant ur.

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That it is the largest cut precious stone known (exclusive of the Cairngorum, which is only Quartz, and much softer) there can be little doubt. It is pure white, and possesses a brilliancy hardly, if ever, equalled in this gem. Its weight is 1,475·9 grains, or 368 carats 3·9 grains; its specific gravity is 3·5685. As to its value, this is simply hypothetical, there being no standard on which to reckon the value of such an exceptionally fine stone.

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X.—*List of Japanese Minerals, with Notes on Species which are believed to be New.*

By John Milne, Yedo, Japan.

DURING the last three years I have been engaged in collecting and cataloguing the minerals of Japan. The following is a list of the species with which I am acquainted. The arrangement is according to the classification given by Dana in his System of Mineralogy.

1. Native Gold
* 2. Native Silver
* 3. Native Copper
* 4. Meteorite (?) two, one from the Bonin Islands, the other from Idzu
5. Amalgam
6. Arsenic ?
7. NATIVE SULPHUR
8. Graphite
9. Realgar
10. Orpiment
11. Antimonite
12. Molybdenite
13. Argentite
14. GALENITE
15. Bornite
16. Sphalerite
17. Cinnabar
*18. Pyrrhotite
19. PYRITE
20. CHALCOPYRITE
21. Mispickel
*22. Tetrahedrite
23. Halite
24. Fluorite ?
25. Hematite
26. Clay Iron Stone
27. MAGNETITE
*28. Chromite
29. Cassiterite
*30. Rutile
31. Pyrolusite
32. Limonite
*33. Psilomelane
34. QUARTZ (rock crystal, amethyst, false topaz, catseye, chalcedony, agate, jasper, flint
35. Opal
36. Wollastonite ?
37. Augite
*38. Spodumene ?
*39. Rhodonite
40. Hornblende, asbestus, &c.
41. Olivine
42. Garnet
43. Epidote
44. Hisingerite ?
45. Vermiculite ?
46. Muscovite
47. Orthoclase—glassy felspar, obsidian, pumice, pitchstone, &c.
48. Tourmaline
49. Topaz
50. Chrysocolla
*51. Analcime
52. Talc (Steatite, &c.)
*53. Meerschaum
54. SERPENTINE

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55. Kaolinite
56. Chlorite
*57. Vivianite?
58. Turquois?
59. Nitre
60. Barite
*61. Anhydrite
62. Gypsum
*63. Chalcanthite
64. Melanterite
65. Alum
66. Alunite?
67. CALCITE (Chalk, &c.)
*68. Dolomite
*69. Aragonite
70. Diallogite
*71. Cerusite
72. Malachite
*73. Azurite
74. Cobalt Ore
75. AMBER
COAL (anthracite, bituminous, lignite, peat, &c.)
*76. Asphalt
*77. PETROLEUM.

Those marked with an asterisk are rare, and I have not yet been able to obtain specimens of them. Doubtful species are followed by a note of interrogation. Names printed in large type indicate common species. Of these latter I have had opportunity of examining many hundreds of specimens. The list has been chiefly compiled from the following sources.

1st. From information gained whilst travelling in various parts of the country (Nipon, Shikoku, Yezo, and the Kuriles.)

2nd. From the extensive collection of minerals placed in my charge by the Mining Department.

3rd. From the large collection of Minerals exhibited at the National Exhibition of Japan, held in Yedo, 1877.

4th. From the collection of minerals exhibited at the exhibition of Kioto, in 1878.

In looking over the above list of minerals the reader cannot fail to observe the absence of many important groups of minerals. Thus, in a country like Japan where the prevailing rocks are of volcanic origin, one would naturally expect to meet with some of the Zeolites. Up to the present I have not been able to meet with any of them, and if they exist at all they are probably extremely rare.

Amongst the metallic minerals a paucity of species will also be observed, a fact which is the more remarkable when we consider the vast number of mines which are being worked. An explanation for this might be that the miners only paid attention to those minerals which were of commercial value. From what I have seen the more probable explanation is that the mines do not yield any variety of ore.

Specimens Nos. 24, 36, 44, 45 are probably new varieties of old species, if not altogether new.

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No. 45. (Vermiculite)? Occurs in short six-sided prisms usually about 6^{mm} long and 3 to 4^{mm} broad. These are made up of a number of laminæ united together at right angles to the length of the prism. The surfaces of these prisms are too irregular to admit of any measurements being made upon them. In order to obtain measurements I took laminæ obtained by cleavage, and after covering them with ink obtained an impression upon paper. The profiles thus obtained were extended by carefully ruled lines, the angles between which gave the angles of the prism.

In three cases the opposite angles of the hexagon were as follows:—

1st ... $\left\{\begin{matrix}127^\circ\ 30' \\ 123^\circ\ 30'\end{matrix}\right\}$ mean $125^\circ\ 30'$ $\left\{\begin{matrix}114^\circ \\ 119^\circ\end{matrix}\right\}$ mean $115^\circ\ 30'$ $\left\{\begin{matrix}118^\circ \\ 116^\circ\end{matrix}\right\}$ mean $117^\circ\ 15'$

2nd ... $\left\{\begin{matrix}126^\circ \\ 130^\circ\end{matrix}\right\}$ mean 128° $\left\{\begin{matrix}116^\circ \\ 115^\circ\ 30'\end{matrix}\right\}$ mean $115^\circ\ 45'$ $\left\{\begin{matrix}120^\circ \\ 111^\circ\end{matrix}\right\}$ mean $115^\circ\ 30'$

3rd ... $\left\{\begin{matrix}124^\circ \\ 121^\circ\ 30'\end{matrix}\right\}$ mean $127^\circ\ 45'$ $\left\{\begin{matrix}119^\circ \\ 118^\circ\ 30'\end{matrix}\right\}$ mean $118^\circ\ 45'$ $\left\{\begin{matrix}116^\circ \\ 119^\circ\ 30'\end{matrix}\right\}$ mean 118°

From these rough measurements it would apparently seem that this mineral is rhombic, the prisms shewing a combination of a basal pinacoid, a prism, and a brachy or macro-pinacoid.

Although I made several sections of this mineral I could only obtain a brownish-red translucent leaf, which gave no distinguishing optical characteristics. From a partial analysis furnished me by Mr. J. H. Collins, it loses 6·41 p.c. of its weight on ignition. In this respect, in some of its blowpipe reactions and in some of its physical appearances, it resembles a Biotite.

It cleaves parallel to the basal pinacoid.

The cleavage surfaces thus obtained have a blackish-green to brown colour, and a brilliant but slightly pearly lustre. The streak is yellowish-brown. Externally the faces of the crystals are covered with an adherent film of ochreous matter.

H. about 1·5; G. about 2·7; fusibility above 5. With nitric and sulphuric acid it dissolves slowly, leaving a residue of silica. With hydrochloric acid it dissolves more quickly, giving a solution changing from brown to green and a residue of silica. When strongly heated either on charcoal or by means of the blowpipe it rapidly expands longitudinally to 6 or even 12 times its original length, at the same time twisting and writhing very like a Pharoah's Serpent. After having been thus heated it breaks up easily into metallic-looking golden scales.

It occurs near Tsurasee on the Kofu side of the Sasango Pass, in the beds of streams running down from granite hills, where it is collected by the inhabitants and sold for medicine, being first burnt before being administered.

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From the odd way in which it writhes upon charcoal it is used by the inhabitants of the neighbourhood as a source of amusement, and it is often shewn to passing travellers, (especially on wet afternoons when time hangs heavily) as a local wonder.

No. 24. Fluorite, var. Chlorophane. This occurs massive. It is of a light-green colour and has a vitreous lustre.

Hardness *about* 4.

Specific gravity in one specimen 3·16, in another 3·13.

With hydrochloric acid or nitric acid when cold there was no change, but with sulphuric acid there was an evolution of gas. When heated with this latter acid it gave much white froth.

On heated platinum it shews a most striking phosphorescence not unlike burning sulphur.

It cleaves readily parallel to the faces of an octahedron, the angles as measured by a hand goniometer being 108° and 71°.

It occurs at the silver mine of Ikuno in Tajima associated with a white mica (Gilbertite ?) quartz and iron pyrites.

It is also found at Hakui in Noto, and at Inabegori in Ise. Some from this latter locality is white and some slightly purplish.

No. 44. Hisingerite ? This is an amorphous black mineral with an external black lustre. Owing to numerous fissures by which it is penetrated, it is very friable.

Streak, greyish-green. Hardness, 2·5—3. Specific gravity, 3·1. Fusibility about 5. With hydrochloric acid it gives a green solution and gas is disengaged slowly. By heat the solution becomes orange-yellow, and with the exception of a flocculent precipitate all is dissolved.

I am indebted to J. H. Collins, Esq., F.G.S., for an analysis of this mineral. He obtained from the mass—silica, 31·35 ; protoxide of iron, 41·76 ; peroxides of iron and alumina, very little ; magnesia, 5·08 ; and water, 7·24 ; but small selected fragments gave,—

Silica	24·5
Protoxide of iron	61·0
Peroxide of iron	3·2
Water	9·8
	98·5

with traces of manganous oxide, lime, magnesia, alumina and potash. Its physical characters so much resemble those of Hisingerite that I propose to refer it to this species, notwithstanding its apparent difference in che-

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cal composition, which may be due to the difficulty in separating it sufficiently pure.

It occurs at the iron mine of Nakaosaka, where it is seen running in irregular veins through deposits of magnetite.

No. 36. Wollastonite? This is a massive pure white mineral with an internal fibrous structure, the fibres radiating somewhat irregularly from various centres.

Specific gravity, 2·82. Is infusible. With hydro-chloric acid a slightly yellowish-green solution is obtained, but with other acids it is unchanged.

From an analysis made by Mr. Tekichi, furnished to me by Dr. Divers, its composition is as follows:—

Calcium Oxide	48·07
Silica	51·63
Iron Oxide	a trace.
Alumina	a slight trace.
Magnesia	absent.
Water	absent.
	99·70

The formula is therefore $Ca\,O, Si\,O_2$.

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XI—*Measurements of Angles of Basaltic Columns in the Giants' Causeway, County of Antrim; made in* 1877,

By Rev. J. H. Jellett, B.D., Fellow of Trinity College, Dublin.*

(A) TETRAGONS. (Sum=360°)

I.	a	90°	IV.	a	115°
	b	91		b	86
	c	87		c	88
	d	91		d	69
		359°			358°
II.	a	79°	V.	a	84°
	b	83		b	87
	c	118		c	88
	d	92		d	96
		372°			355°
III.	a	74°	VI.	a	90°
	b	100		b	80
	c	93		c	82
	d	90		d	102
		357°			354°

(B) PENTAGONS (Sum=540°)

I.	a	103°	III.	a	117°
	b	115		b	109
	c	96		c	113
	d	110		d	83
	e	115		e	103
		539°			525°
II.	a	108°	IV.	a	115°
	b	109		b	122
	c	106		c	124
	d	113		d	74
	e	99		e	105
		535°			540°

* Communicated by Rev. Samuel Haughton, M.D.

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V.
a ——103°
b ——102
c ——118
d ——113
e —— 97
533°

VI.
a ——105°
b ——127
c ——128
d —— 83
e —— 91
534°

(C) HEXAGONS (Sum=720°)

I.
a ——142°
b ——137
c —— 86
d ——119
e ——130
f ——109
723°

II.
a ——106°
b ——116
c ——130
d ——110
e ——130
f ——124
716°

III.
a ——115°
b ——129
c ——123
d ——127
e ——121
f ——164
719°

(D) HEPTAGONS (Sum=900°)

I.
a ——107°
b ——115
c ——139
d ——139
e ——140
f ——128
g ——139
907°

II.
a ——126°
b ——138
c ——129
d ——115
e ——130
f ——120
g ——125
883°

III.
a ——133°
b ——129
c ——108
d ——113
e ——124
f ——143
g ——135
885°

IV.
a ——120°
b ——130
c ——142
d ——122
e ——137
f ——131
g ——115
897°

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V.		VI.	
a	140°	a	127°
b	125	b	118
c	143	c	136
d	143	d	131
e	128	e	122
f	117	f	118
g	119	g	140
	915°		892°

(E) OCTAGONS (Sum=1080°)

I.		III.	
a	138°	a	138°
b	130	b	129
c	137	c	144
d	144	d	135
e	130	e	146
f	120	f	138
g	143	g	132
h	140	h	125
	1082°		1087°

II.		IV.	
a	166°	a	127°
b	143	b	140
c	138	c	144
d	120	d	133
e	117	e	131
f	139	f	140
g	140	g	140
h	127	h	115
	1090°		1078°

With regard to the relative frequency of the several kinds of columns, Professor O'Reilly, of the Royal College of Science for Ireland, makes the two following estimates:*—

1°. Out of 200 columns observed—

Tetragons	3·54 per cent.
Pentagons	24·75
Hexagons	50·50
Heptagons	19·19
Octagons	2·02
	100·00

2°. Professor O'Reilly took another and perfectly independent measure by laying down a line of 50^{m} long, in another part of the Causeway,

* In a letter addressed to Dr. Haughton, 18th June, 1878.

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and then counting the number and nature of the Polygons which the line crossed. The result was as follows :—

Tetragons	3	1·98 per cent.
Pentagons	47	30·73
Hexagons	72	47·00
Heptagons	30	19·63
Octagons	1	0·66
	153	100·00

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Reviews and Notices.

On the remarkable new Mineral locality in Fairfield County, Connecticut, &c., by Geo. J. Brush and E. S. Dana.

UNDER this title the authors describe* a remarkable assemblage of seven well-defined mineral phosphates, four of which, viz., Eosphorite, Dickinsonite, Triploidite, and Lithiophilite, have already been adverted to in the pages of the Mineralogical Magazine, vol. II, p. 100. The other three are named Reddingtonite, Fairfieldite, and Fillowite respectively.

The chief characters of all the seven are given in a tabular form below for easy reference.

	H	G	APPEARANCE.	FUS.
Eosphorite ..	5	3·132—3·145,	often resembles green elæolite	4
Triploidite ..	4·5-5	3·697 ..	yellowish to reddish-brown	1
Dickinsonite ..	3·5-4	3·338 ..	various shades of green ..	1
Lithiophilite ..	4·	3·424 ..	salmon-coloured	1-1·5
Reddingtonite	3-3·5	3·102 ..	yellowish-white	2
Fairfieldite ..	3·5	3·15 ..	white to pale straw-yellow	4·5
Fillowite ..	4·5	3·41—3·45	yellowish to reddish-brown	1·5
Altered *Lithiophilite*	3-4	3·26—3·40	black to purple	

Lithiophilite is anhydrous, the others are hydrous; all are soluble in HCl or HNO_3; all are transparent to translucent.

The formulæ of the minerals is given below.

Eosphorite ..	$R_2Al_2P_2O_{10}$, $4H_2O$	or	$Al_2P_2O_8+2H_2Mn(Fe)O_2+2H_2O$
Triploidite ..	$R_4P_2O_9$, H_2O	or	$Mn_3(Fe_3)P_2O_8+Mn(Fe)H_2O$
Dickinsonite	$4(R_3P_2O_8)$, $3H_2O$	or	$4(MnFeCaNa_2)\ 3P_2O_8+3H_2O$
Lithiophilite	$LiMnPO_4$	or	$Li_3PO_4+Mn_3P_2O_8$
Reddingtonite	$R_3P_2O_8$, $3H_2O$	or	$Mn_3(Fe_3)P_2O_8+3H_2O$
Fairfieldite ..	$R_3P_2O_8$, $2H_2O$	or	$Ca_3(Mn_3Fe_3)P_2O_8+2H_2O$
Fillowite ..	$3R_3P_2O_8$, H_2O	or	$3(MnFeCaNa_2)_3P_2O_8$; H_2O

* Am. Journ. Sci., July and August, 1878, and May 1879.

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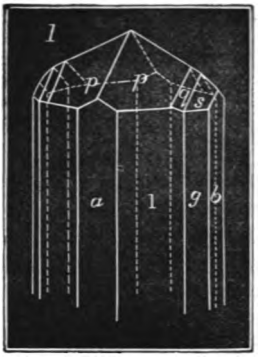
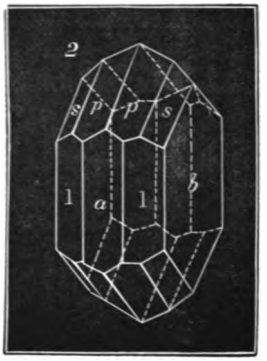
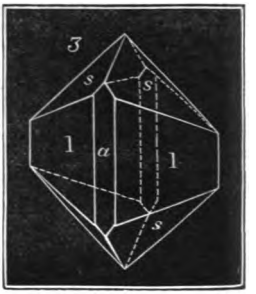
Eosphorite is Rhombic in crystallization, the form being related to Childrenite as shewn in the accompanying figures, where fig. 1 represents one of the crystals, while fig. 2 is a crystal of Childrenite, from Hebron, Maine; and fig. 3 a crystal of Childrenite, from Tavistock; the three crystals being drawn in similar positions.

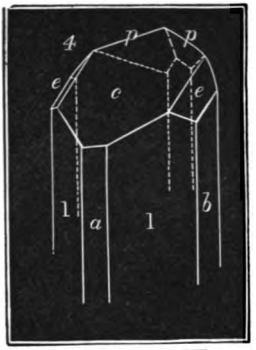






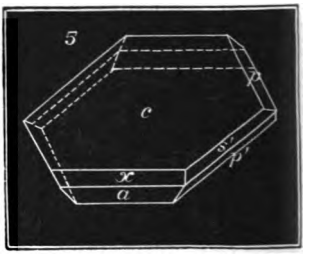
In order to bring the crystals of Childrenite into this position, the clinodome (n of Miller) is made the unit prism. The crystals are distinctly trichroic. The axial colours are as follows:—

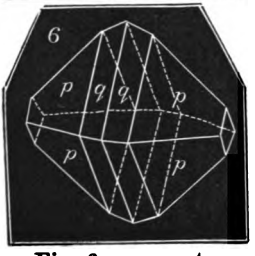
α (b Miller) yellowish.
β (a Miller) deep pink.
γ (c Miller) faint pink.



Triploidite is oblique and homeomorphous, with Wagnerite; the form of the crystals is given in fig. 4.

Dickinsonite is also oblique, but the crystals have a marked rhombohedral (hexagonal) aspect, as seen in fig. 5. It is distinctly dichroic.





Reddingtonite is *Rhombic*, and nearly related in form to Scorodite and Strengite (this Magazine Vol. II, p. 99). The axial ratios of the three species are as follows:

	c *(vert)*	$\bar{b}$	$\breve{a}$
Reddingtonite....	1·0930	1·1524	1·
Scorodite (*Vom Rath.*)	1·1020	1·1530	1·
Strengite *(Nies)*....	1·1224	1·1855	1·

Fig. 6 represents a crystal of Reddingtonite.

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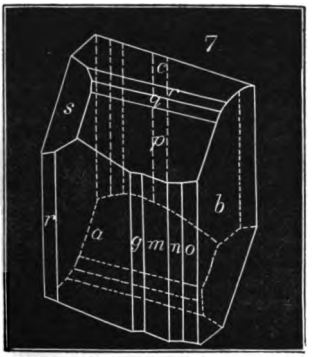
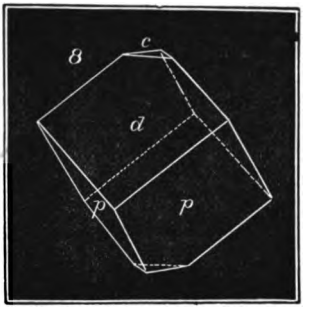
Fairfieldite is Anorthic, as shewn in fig. 7.





Fillowite is oblique, but with distinctly rhombohedral aspect. as shewn in fig. 8.

STIBIANITE.—(E. GOLDSMITH, *Proc. Acad. Nat. Sci., Philadelphia*, 1878, *p.* 154.)—This mineral is from Victoria, Australia. It is massive, somewhat porous, reddish-yellow, but not uniformly; dull; H=5; G=3·66 BB on with soda C, yields antimony reactions, gives no colour to a bead of micro. In matrass yields water, soluble in HCl, Aqua Regia, KHO and SHAm; the solubility in KHO indicates absence of antimonious acid, while a solution of sulphate of copper shews presence of antimonic acid.

Analysis shews—94·79 p.c. of antimonic anhydride, and 5·21 of water, yielding the formula $Sb_2O_5H_2O$.

STAFFELITE.—(*Ibid p.* 157).—This occurs on the well-known Amazon stone of Pike's Peak, Colorado.

HUNTILITE.—(*Wurtz. Engineer and Min. Journ., N.Y., Jan.* 25, 1879). Occurs in two varieties. The most abundant variety is amorphous—often porous, dark slate-grey or almost black; dull. The crystalline variety is cleavable in one direction, and of a lighter slate-colour. H about 2·5, streak bronze-coloured, sub-malleable. Probable formula $As Ag_3$. Occurs at the Silver Islet Mine, Lake Superior. Named after Dr. Sterry Hunt.

RANDITE.—(G. A. KOENIG, *Proc. Acad. Nat. Sci., Phil.*, 1878, 408.) Earthy probably crystalline; H=2·3. Probable formula $Ca_5 U_2 C_6 O_{20} + 3H_2O$, which would place it near Liebigite. Named after Dr. D. Ran[illegible] of Philadelphia.

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ANIMIKITE.—(*Ibid.*)—Occurs alone or with Huntilite; G=9·45; white or grayish-white; fracture fine granular; conchoidal. Analysis gives

Sb.	11·18
As.	·35
S.	1·49
Hg.	·99
Ag.	77·58
Co.	2·10
Ni.	1·90
Fe.	1·68
Zn.	·30
Gangue.	1·68
Total	99 25

Found at Silver Islet Mine, Lake Superior. Named from an Indian word meaning *Thunder*—whence Thunder Bay.

HANNAYITE.—(VOM RATH. BALL, *Soc, Min., France*, 79, 1879.)—Triclinic. Basal cleavage perfect, less perfect parallel to two prismatic planes. G=1·893. Mean of two analyses gave

P_2O_5	45·70
MgO	18·90
NH_3	8·09
H_2O	28·20
	100·89

21·08 p.c. of water lost between 100° and 120° C. Found at the Skipton Caves, Victoria.

NEWBERYITE.—(*Ibid.*)—Rhombic. Cleavage brachydiagonal, perfect; basal, imperfect; analysis gave

P_2O_5	41·25
MgO (diff) ..	23·02
H_2O	35·73
	100·00

Probable formula $Mg_2P_2O_7 + 7Aq$. Found at Skipton Caves, Victoria, with Hannayite.

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Obituary.

W. R. Williams was born 7th January, 1828. He was in practice as a civil and mining engineer for about 30 years in the Dolgelly district, that is including Festiniog, Corris, &c., slate quarrying districts; and frequently called away to more distant places, both in North and South Wales to report and advise in slate quarrying and mining. He was largely connected with gold mining in North Wales, and one of the first engaged in it. His practice also included civil engineering, surveying and valuing, to a very considerable extent, as well as architecture and estate agency in a general country practice. He was for some years prior to his death chairman of the School Board in the parish of Dolgelly, and generally took an active part in all the public affairs appertaining to this part of the country. He was elected a Fellow of the Geological Society of London in 1865. During the whole 30 years of his practice he associated himself with most of the improvements in the Dolgelly district. He died at Vron-Arran, on the 11th January, 1879.

William Vivian was born in the parish of Kea, Cornwall, 2nd June, 1817. He entered the service of Messrs. J. Taylor and Sons, in 1853. Was manager of Parys Mines, Anglesea, 1860. Was appointed manager of Mwyndy Iron Ore Mines, Glamorganshire, on the 1st August, 1863, and died at the mines on the 18th April, 1879.

His kindly disposition endeared him to all who knew him, and he generally managed to impart a portion of his enthusiasm for the beauties of microscopic crystals to every visitor, whether a mineralogist or not, by exhibiting to him under the two inch power of the microscope, the numerous crystal-lined caves and tunnels so abundantly to be seen in vein-stones, glass, and furnace products. Although in failing health for several years, he was taken away rather suddenly at last. He suffered from congestion of the lungs for about a week, but became much worse on the night of the 17th April, 1879, and died at 6.30 on the morning of the 18th.

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The following is a list of his scientific papers:—

Observations on the mining district of Sonora, Tuolumne Co., California. (1852) Trans. R.G.S.C. VII, 216-19.

Observations on the gold fields of the Pacific coast, and their prboable extent. (1858) *ib.* VII, 327-31.

Constitution and structure of slate. (1858) *ib.* 339-42.

Essay on the more perfect opening and ventilation of mines. Rep. R.C.P. Soc. (1855) p. XVII.

Observations on the crystalline forms of native metals. *Ib.* (1859) pp. 46-48.

On the arborescent native copper in the Llandudno Mine, near Great Orme's head, North Wales. Journ. Geol. Soc. XV, 109-10 (1858).

Practical mining, &c. Letters in H. C. Salmon's Mining and Smelting Mag. Vol. I, (1862).

Microscopic observations on the structure of metals. Rep. Brit. Assoc. (1862), Pt. II, p. 34.

On the cellular structure of metallic iron. Proc. of S. Wales Inst. of Engineers, V. 129, 179-81, (1866).

On the application of the microscope to the study of mineralogy and metallurgy. Trans. Cardiff Naturalist Soc., 1868-69, p. 13.

Water—Its conditions of solid, fluid, and vapour. *Ib.* 1871.

On the use of the microscope in mineralogy, geology, and metallurgy. Western Chronicle of Science, I, 199-204, (1872).

Miners' Diseases. *Ib.* I, 205-206.

Notes on the oxides of iron enclosed in Quartz, at Mwyndy, Glamorganshire. Min. Mag., Nos. 1 and 4, (1877).

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THE MINERALOGICAL MAGAZINE

AND

JOURNAL

OF THE

MINERALOGICAL SOCIETY OF GREAT BRITAIN AND IRELAND

No. 14. OCTOBER, 1879. Vol. III.

XII.—*On the cause of the production of different secondary forms of crystals.*

By H. C. Sorby, LL.D., F.R.S.; President G.S., &c.

IT has often struck me that much more might be learned from the study of the secondary forms of crystalline minerals than we now know respecting the circumstances under which they were produced. Some years ago being chiefly acquainted with calcite as it occurs in Derbyshire, where the crystals are usually of the so-called dog-tooth shape, my attention was much attracted by the difference in the form of the crystals in Devonshire and Cornwall, where we so often meet with six-sided prisms. On reflecting on this difference I could not give any more satisfactory explanation than that the conditions under which they were formed must have been very different in some important particular. Various experiments, made both before and afterwards, sufficed to indicate at all events some of the possible causes of such a difference in the form of this mineral, but at the same time showed clearly that much special research would be required before we could draw such definite conclusions as could be desired. I feel that the facts I now propose to describe are very imperfect, but yet for a long time have wished to say something about them, if only to lead others to work out the subject more completely.

My first experiments were made with carbonate of lime. I prepared aqueous solutions of this substance in carbonic acid, and evaporated them at various slightly different temperatures. I also evaporated in a similar

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manner solutions containing in addition to carbonate of lime, small quantities of the carbonates of iron and of magnesia. It soon became apparent that the number of varying forms that could thus be prepared was very great, but I did not not continue the experiments sufficiently to enable me to draw any complete detailed conclusions. I however convinced myself that small differences in temperature, and the presence of small quantities of foreign substances were sufficient to give rise to very varying secondary forms in the crystals, and not only so, but that the conditions under which they were formed—for example whether at the surface or at the bottom—had also an important influence. Some of the results had a direct bearing on mineralogy, and sufficed to explain the cause of the production of certain characteristic crystals. Thus, for instance, the presence of a small quantity of magnesia, gave rise to crystals of the rhombohedral shape, so commonly met with in limestones containing much magnesia.

Some time after this I was engaged in studying the fluid cavities met in chloride of potassium, and for this purpose prepared many crystals by slow spontaneous evaporation. At first I obtained some solid, partially transparent cubic crystals, very suitable for my purpose, but afterwards, when using the same material I was unable to obtain more crystals of the same character, which I was very anxious to do. On the contrary every time that I prepared a fresh crop, I obtained crystals differing not only from those first made, but also from one another, all of which I carefully preserved, until I had got a most instructive collection. The only explanation I could give of the facts was that during the time when I was making these experiments the temperature of the atmosphere had slowly changed, and that the production of all the various forms of the crystals obtained had depended upon a comparatively small variation in the temperature.

In preparing for microscopical purposes crystals of other substances, I have in some cases remarked no such tendency to vary, but in other cases have been completely unable to procure a second time crystals of a particular character. Thus, for example, I was once able to make some excellent thin, flat, rhombic plates of chlorate of potash, coloured with permanganate, and being most excellent spectroscope objects I was anxious to procure more of them. I endeavoured to do so over and over again, and though I prepared many hundred crystals, I could never obtain any more of the same plate-like character, nor could ascertain what had been the peculiar conditions under which they had been formed.

I cannot doubt that such facts as these must have been often noticed before, though they may not have attracted such particular attention. I cannot but think that good service might be done to the science of miner-

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alogy by anyone who would adequately devote his attention to this kind of enquiry. The facts which I have described are so limited in their range that I feel almost ashamed to draw attention to them, but yet I think they serve to prove very clearly that, independent of the rate of deposition, comparatively small difference in the temperature of the water, and the presence of small quantities of other substances, may cause such a marked difference in the general form and character of the crystals of a substance deposited from it, as would serve well enough to explain the production of the varying secondary forms of natural minerals. Possibly this will readily be admitted, but a much more difficult question then arises, which is to correlate the known secondary forms with the unknown conditions under which they were produced. If this could be done, it would, I doubt not, be a great gain for geology, and would throw much light on many interesting questions. I see no reason why we should not learn as much from the detailed study of minerals as we have learned from the detailed study of fossil organisms.

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XIII.—*Note on a Crystallized Slag isomorphous with Olivine.*

By A. E. Arnold.

Communicated by J. H. Collins.

THE crystals referred to were found in considerable quantity in the slags produced in Mr. Hollway's experiments on the reduction of metallic sulphides at Penistone, in July 1878.

The experiments were carried out with ordinary Bessemer plant. Upon running the molten mass from the ladle into one of the ingot moulds the slag ran in a thick stream of perfect continuity, falling without noise a distance of some feet into the liquid portion below. The crystals occurred lining cavities in the partially cooled slag from which a portion of the molten material had been withdrawn.

Some of them were extremely well formed and they varied in size from about 1-100th to $\frac{1}{2}^{th}$ of an inch in length, and somewhat less in breadth and thickness.

After careful separation from contiguous substance the crystals were analysed in duplicate with the following results,—

	I	II	Calculated on 13 $\left.\begin{matrix}FeO\\FeS\end{matrix}\right\}$ 7 SiO_2
SiO_2	28·99	29·06	29·08
FeS	.. ..	6·10	6·09
FeO	.. ..	61·34	64·82
Al_2O_3 ..	.. ..	60	
Cu	.. ..	14	
MnO, ZnO ..	.. ..	2·78	
		100·02	99·99
Sp. Gr	4·19	4.22	

By adding together the basic oxygen and half the sulphur the sum is found to equal the oxygen of the SiO_2 showing that the presence of FeS cannot be accidental. If the analyses of slags I, II, III, V, of the July, 1878, Penistone experiments be similarly calculated into basic and acid oxygen, the fact is revealed that the sulphur takes part as a basic element in the constitution of the slag, so that we really have a silicate of a metallic sulphide.

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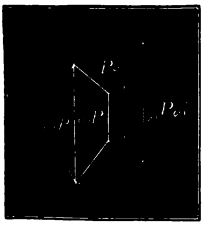

Some of the crystals referred to have been examined by Dr. C. O. Trechmann, of Hartlepool, who states that they exhibit the forms shewn in the figure. He considers them to be artificial Fayalite, regarding the FeS present as a mere mechanical admixture, but its large quantity, and its proportion, *exactly* replacing one molecule of the ferrous oxide would seem to indicate that it is a true chemical compound. It differs from the mineral Helvin not only in crystallization but in having two atoms of metal to one of silica, whereas the latter contains seven of metal to three of silica.

I have tried the artificial formation of sulphosilicates, by passing H_2S over metallic silicates. With 2 FeO SiO_2 I have not yet succeeded, the result I obtained being

$$2FeO\ SiO_2 + 2H_2S = 2\ FeS + 2H_2O + SiO_2$$

which is somewhat interesting.

The existence of sulphosilicates of iron was first suspected by Leplay, but he was unable to prove the hypothesis he enunciated. He observed that slags produced in the smelting of copper ores by the Swansea process invariably contained more sulphide of iron than could be accounted for by the presence of entangled regulus. The following examples may be cited to show how certain metallic sulphides may play the part of basic oxides in these artificial silicates. In the Penistone experiments crystalline homogeneous slags were produced of the orthosilicate type, which should contain therefore equal quantities of oxygen in acid and basic combination according to the formula $2M''O, SiO_2$. Now it appears from the analyses made by Mr. J. E. Stead and myself that there is a slight deficit in the amount of the basic oxygen which is almost exactly compensated for by adding to it half the percentage of sulphur (O = 16 replaced by S = 32) found to be present.

In the following analysis by Mr. J. E. Stead, it will be seen that the total oxygen found in the bases amounts to 14·382 per cent. In the operation in which this slag was produced the regulus obtained contained 15·8 per cent. of copper and 21·96 per cent. of sulphur. Casting out by means of these data the amount of sulphur present as regulus in the slag estimated on the 0·16 per cent. of copper present, we find we have to subtract 0.223 per cent. of sulphur from the sulphur found; 3·39 per cent $-$ ·223 per cent. = 3·167 per cent. which represents the sulphur replacing oxygen in the sulphosilicate. The equivalent of this in oxygen is 1.583 per cent.

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Iron Protoxide	53·30%	Oxygen =	11·844%	
,, Peroxide	8·00	,, =	0·900	
Iron comb. with Sulphur	5·79			
Copper ,, ,, ,,	0·16			
Lead	0·12			
Zinc Oxide	1·15	,, =	0·269	14·382%
Arsenic	trace			
Manganese Oxide ..	0·32	,, =	0·071	
Alumina	2·15	,, =	1·000	
Lime	0·40	,, =	0·114	
Magnesia	0·46	,, =	0·184	
Sulphur	3·39			
Silica	29.90	Oxygen =	15·933%	
	100.14			

Basic oxygen present	14·382%
Basic sulphur ,, Calculated into oxygen	1.583 ,,
	15·965%

The oxygen calculated from 29·90% SiO_2 = 15·933%

Similarly in a second analysis by the same analyst analogous results are obtained on calculation.

Iron Protoxide	54·62%	Oxygen =	12·138%	
,, Peroxide	3·71	,, =	1·113	
Iron comb. with Sulphur	4·27			
Copper ,, ,, ,,	0·22			
Lead	0·10			
Zinc Oxide	1·75	,, =	0·348	14·927%
Arsenic	trace			
Manganese Oxide ..	0·37	,, =	0·082	
Alumina	0·06	,, =	0·960	
Lime	0·37	,, =	0·106	
Magnesia	0.45	,, =	0·180	
Sulphur	2.55			
Silica	30·05	Oxygen =	16·027	
	100·52			

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The regulus produced contained 16·6 per cent. of copper and 23·5 per cent. of sulphur: 0·22 per cent. of copper in slag corresponds to ·311 per cent. reguline sulphur.

Total oxygen of Bases	14·927%
Oxygen replaced by Sulphur $= \frac{2·55—·311}{2}$	1·119
	16·046%
Oxygen of Silica	16·027%

It is probable that sulphur exists in blast and puddling furnace slags in the form of sulphosilicate. It is well known that manganese exercises an affinity for sulphur in the presence of silicious fluxes, which calls to mind the fact that the only natural sulphosilicate known is that of manganese.

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XIV.—*Preliminary Note on old Rhyolites from Bouley Bay, Jersey, &c.*

By Thos. Davies, F.G.S. of the Mineral Department, British Museum.

THE examination of the rhyolite exhumed by Dr. Henry Hicks, F.G.S., from the conglomerate of the Pebidian formation of St. Davids, Pembrokeshire (*Quart. Journ. Geol. Soc., May.*, 1878, p. 153), recalled to my mind certain rocks from other localities which had found a place in the large and important petrological collection in the British Museum, which I thought might prove to belong to the same group. Among these, some fragments brought from Bouley Bay, Jersey, by Wm. Carruthers, Esq., F.R.S., whose attention they attracted, interested me especially. It was found, however, that they had not been collected with the view of illustrating the rock in all its varieties, so further examination was postponed until an opportunity occurred to procure more material.

To the kindness of Dr. Andrew Dunlop, F.G.S., of Jersey, I am now indebted for a selection from his own collection of such pieces as he considers will afford a sufficient representation of it in all its varied aspects.

The names "hornstone" and "hornstone porphyry" by which these rocks have been designated, sufficiently suggest their general aspect, but the spherular character of a considerable portion of it appears to have escaped the observation of previous writers.

The revelations of the microscope confirm in the most conclusive manner the view derived from a macroscopical examination. They are true rhyolites, although the subsequent alteration they have undergone through devitrification and the effects of hydrothermal agencies, are in some parts very considerable. Yet the perlitic and spherulitic structures so well exhibited by some of the younger outflows are preserved, the former shewing as distinctly as in their modern representatives. The spherular development is, however, in most cases, much more marked in these older rhyolites than in their younger equivalents, this structure varying from minute spherular groupings without a peripheral definition to distinct bodies easily separable from the mass, which vary in size from that of a pea to over two inches in diameter. Sometimes they occur developed in parallel bands resembling those in the obsidian of the Lipari Islands, but usually they are irregularly distributed through the mass. Occasionally

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the perlitic and spherulitic structures are combined, thus supplying undoubted evidence of their original vitreous condition.

Dr. Dunlop informs me that these rocks extend from Bouley Bay across the N.E. corner of the island to St. Catherine's Bay. To the N.E. they are overlain by a conglomerate or rather breccia, which consists largely of the shale forming a large part of the island, with some syenite (probably hornblendic granite); but that near the rhyolites fragments of these are very frequent in it. He also points out that at Anne Port, forming the S. point of Saint Catherine's Bay, the Bouley Bay rocks appear to pass into a "porphyry." This, on examination is resolved into a quartz felsite, and it affords additional evidence of a view I have for some time entertained as to the identity of composition, structure, and origin of a large part of the quartz felsites with the modern rhyolites.

To this group belongs some fragments of a boulder given to the Museum by Spencer G. Perceval, Esq., which formerly existed near Old Cleeve, Somerset, in which the spherules are as large as a cricket-ball, and the mass of which exhibits the fluidal structure in a marked manner. Another rock from the drift at Hartlebury Common, Worcestershire, also collected by Mr. Perceval, belongs here.

Detailed descriptions of all these rocks now in course of being worked out, together with some notes upon the relations of the quartz-felsites to the rhyolites, will form the subject of a communication to the next meeting of the Society.

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XV.—*Note on the Minerals of the Island of Cyprus.*

By J. H. Collins, F.G.S.

I have lately had the opportunity of conversing with one of our members, Mr. Jos. Jewell, who has been making an inspection of some parts of the island of Cyprus for mining purposes, and having been called upon by other parties to report on a number of mineral specimens brought from that island, I have thought that a short note on the subject might be of some interest to the members generally.

So much has been said of the mineral riches of the island, that I was astonished at the comparative poverty of the specimens brought home, and also at the very small number of mineral species which the island has so far yielded. It is indeed evident that large quantities of ores have been worked in the island in former times as is shewn by the extent of some of the excavations and by the immense heaps of slag described by M. Albert Gaudry, but no rich deposits seem to be in existence now, so far as is yet known. With regard to the excavations at one of the principal localities, that of Bellahousa, Mr. Jos. Jewell reports as follows:—

The mountain in which the copper-ore is found consists of more or less decomposed limestone intermixed with layers of red and yellow ochre, and containing several bands of porphyry and small veins of iron pyrites.

The mines are approached by a deep and narrow valley which runs up direct from the sea-shore. In No. 1 mine on the south side of the valley two levels are driven into the mountains for distances of 3 and 15 fathoms respectively. These open into large chambers which have been excavated in a mixed "conglomerate" of black earthy matter containing masses of limestone, blue and green carbonate of copper, and sulphate of iron, together with layers of sand and pebbles. No. 2 mine is also entered by a short level, and consists of chambers excavated in a similar black earthy mass. Some of these chambers are 80 feet long, 60 feet wide, and 20 feet high. These "conglomerates" contain from 2 to 3 per cent of copper, but of course the parts worked away may have been much richer.

The limestone hills on the north side of the valley contain a large quantity of red and yellow ochre containing from 1½ to 3 per cent. of copper, together with some particles of blende. By sinking pits in this mass some small lumps of carbonates of copper were found, yielding from to 14 per cent of copper.

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Somewhat further up the valley is a mine which has been worked in a mass of iron pyrites containing a small proportion of copper. In the same mountains, at some little distance, is a large deposit of black oxide of manganese.

It is difficult to see how such poor ores could be worked by the ancient miners of Cyprus, unless an abundance of fuel were obtainable. Had there been forests no doubt such free smelting ores might have been worked to considerable advantage. It is clear, however, that such ores will not pay for smelting now by the Welsh process, and not being pyritous ores they will not be adapted for the Hollway process unless they are worked in connexion with the large deposit of pyritous material above referred to.

The following list gives the names of all the mineral species of the island which have been observed up to the present time, so far as is known to the writer:—

List of Minerals found in Cyprus.

Serpentine. Mount Troödos,
Saussurite } in Gabbro, ,,
Diallage }
Hematite. Lesso. Lithrodonta, Hai Héracliti, Stavio Vormi, &c., (Specular Iron.)
Limonite. Many localities, G.
Pyrites. Dginhoussa and many other places.
Melanterite. Dginhoussa.
Peroxide of Manganese. Visatchia, and Acoutzo, G.
Jasper.
Rock Crystal
Malachite.
Chessylite.
Chalcopyrite.
Gypsum.
Chrysocolla.
Allophane.
Cyanosite.
Melaconite.
Titaniferous Iron Ore.
Galena.
Blende.
Calamine.
Analcime (Cyprian diamonds).

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XVI.—*Notes on some Minerals of the Mawddach Valley.*

By T. A. Readwin, F.G.S. &c.

THE late eminent palæontologist, Mr. Salter, F.G.S., characterized the portion of the lovely valley of the Mawddach, at, and near the Falls of the Cain and Mawddach Rivers, "a perfect geological puzzle."

Certain it is, that touching Tyddyngwladus, the survey maps are greatly at fault; and, that the rocks, thereabouts, most of them, are of *pre-cambrian* age.

Dr. Hicks, F.G.S., has hit upon the truth, approximately, I think, in what he calls *Dimetian* at St. David's, (as applied to the lowest beds of this district.)

After more than a year's unceasing investigation of these puzzling rocks and their associated minerals (chiefly with reference to the modes of occurrence of the "precious metals"). I must frankly acknowledge that the locality geologically, to my comprehension, remains pretty much as Salter left it, a "puzzle."

I am quite content to leave the exact order of superposition of these rocks in the hands of the geologists; and, will briefly state that the hand-specimens I have collected show:—

Black micaceous and talcose schists; black and green shales; hard, dark-grey, felspathic, ashy, and cindery-looking uncleavable (for the most part,) slates; (*lower silurian* of the survey). Black slates, (*upper cambrian* or *lingula-flags* of the survey). Felspathic and "Trappean" grits; hard coarse sandstone; rough schists, shales and slates (*lower cambrian* of the survey.)

Portions of felspathic-lava beds; striped cinder-beds, both chloritic and mixed with grit and sandstone; spotted, blotched, felspathic, sedimentary and interbedded "trap-rocks."

Bits of ashy-beds, yellow clay, "Elvan," "Flookan," and quartzite.

The usual "intrusive greenstones" of the survey, which are green, grey, and reddish in colour, fine, medium, and coarse-grained, often very coarse-grained, prominently quartzose, and, prominently hornblendic; also, diabase, and diorite, and the "magnificent uralite porphyry."

The minerals include compact and crystallized baryte, calcite (sparsely), orthoclase, chlorite, black hornblende, white scaly mica, white, yellow,

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ferruginous, calciferous, auriferous, plumbiferous, zinciferous, cupriferous and pyritous quartz, with the cherty or hornstone variety abounding, which is often powdered (so to speak) with extremely fine gold, all of which is so light that it will float on water. Talc also, occasionally, and uralite. Native gold, native silver, native antimony, native copper, galena, copper pyrites, iron pyrites, mispickel, marcasite, rhodochrosite, tetrahedrite, polytelite (of D. Forbes,) pyromorphite, blende, stibnite, senarmontite, berthierite (?), aphthonite (of Glocker ?), earthy malachite, platinum (?), titanoferrite (of Forbes), &c.; some interesting particulars of which I reserve for other occasions.

Gold is found *in situ* in the metallic state, of a very pale yellow color. As yet, it has not been found in anything approaching geometric forms of crystallization. Generally, the gold is disseminated in whitish crystalline quartz, or in hornstone, in a state of division so minute as to be scarcely discernible by the aid of a powerful lens. Occasionally, this precious metal is found something like what Sir R. Murchison characterised as "crystallised twigs." This gold as found answers to *Pliny's* "electrum," containing from 10 to 15 or more per cent of combined silver.

Much has been said about 'derivative forms' of gold; but from a long series of observations, I cannot be persuaded to believe in derivative forms, touching systematic crystallization. I believe, rather, that gold, hereabouts, is frequently contained in quartz in a *non-metallic* state; and that, in process of time, be it short or long, particles of gold in ever-varying shapes (not definite forms) increase palpably in size and weight, even in and upon quartz apparently wholly destitute of the ordinarily associated metallic sulphides.

I have treated this subject at great length in a former number of the Mineralogical Magazine.*

Some of the specimens described in that paper, have since given me ample proof that I am altogether in the right about it. And recent repeated analyses convince me too, that gold exists here in a state of sulphide, and *probably* in some other state, or states, not yet generally known.

The electrum here, is frequently in quartz more or less surrounded with galena, blende, iron pyrites, copper pyrites (chalcopyrite of *Dana*), mispickel, (arsenopyrite of *Dana*) marcasite! But chiefly with galena and blende, and a proustite-looking mineral, an exceptional condition of blende.

I have treated many specimens of galena in quartz with hot acids, got rid of the sulphide, and obtained the electrum theretofore enclosed within

* No. 5, p. 158.

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it, growing, as it were, out of the quartz, which could then, sometimes, become easily detached.

I have some reason for believing that the galena in such cases is the more recent mineral-aggregate.

I find, also, electrum in argentiferous galena, altogether unassociated with quartz, or other metalloid.

I find bits of gold of several grains weight in the sand and silt of the River Mawddach.

This stream-gold is worth 5s. an ounce more than the electrum which is found disseminated throughout the lode-stuff generally.

I gave my friend the late D. Forbes, F.R.S., a goodly sample of this stream-gold, and the following is what he wrote of it.

"The portion received contains the native gold in the form of small flattened, elongated spangles, in size from about a pinshead, down to almost dust, and of a rich yellow colour; it was accompanied by abundance of fine black sand, supposed to be magnetic oxide of iron, from its being strongly attracted by the magnet, but which, on analysis turned out to be titanoferrite. It also contained small particles of quartz, slate-rock, mica, and some small cubes of iron pyrites and galena.

The specific gravity of the gold, carefully separated from any other admixture, was found to be 15·79 at 60°F.; quantity employed 22·75 grs.

20·16 grs. afforded 17·71 grs. metallic gold; 3·89 grs. chloride of silver; 0·09 gr. insoluble quartz; and, 0·10 gr. sesquioxide of iron.

The results when calculated give :—

Gold..	17·71	=	84·99
Silver	2·92	=	13·99
Iron	0·07	=	0·34
Quartz	0·09	=	0·43
Cu & Loss	0·07	=	0·35
	20·86	=	100·00

Several of the largest spangles of gold appeared of a peculiar rich color, owing to their being coated with, as it were, a varnish or thin film of sesquioxide of iron, which persistently adhered to their surface; and, probably, was the source of a part, if not of all the iron found by analysis. This coating was no doubt the cause of the gold appearing to the eye considerably richer than it actually turned out to be, on assay."*

I have very recently washed out about half an ounce of similar gold (only chiefly in larger pieces) from the same locality.

* *Philosophical Magazine, Nov.* 1867.

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It is associated with bits of galena, blende, titanoferrite (of Forbes), quartz, marcasite, and fragments of rock-debris.

The iron is removable by a magnet, but particles of gold will also adhere.

Some of this spangle-gold is tarnished as Forbes describes, but it is generally tarnished by titanic acid; and the tarnish is instantly removed by sodium or potassium amalgam, and will then yield to the ordinary processes of amalgamation. Without taking into account the greater pureness of this stream-gold, compared with the electrum of the lode-stuff, I think it more than probable that it did not originate at Tyddyn-gwladus at all. It was more likely brought down by the Mawddach floods from the Gwynfynydd or Cwmheisian mountains, or from still nearer the sources of the Cain and Mawddach rivers.

In my paper on 'Mineral Growth at ordinary temperatures,' already referred to, I have shown, that at times, under apparently ordinary conditions, gold, silver, copper and iron suddenly exude from the surface of the minerals (especially gold from quartz, and silver from calcite and argentite); and this extrusion for convenience of expression I termed 'Mineral Growth.'

The expression does not happen to be generally acceptable to the mineralogical mind; but the metals 'grow' (in the sense I mean it) for all that.

In that paper I referred to a lump of white quartz weighing half a hundred weight, which once occupied a place in a 'rockery' in a fern-corner of my garden.

This stone in December, 1877, shot out a 'crystallized twig' of electrum-gold more than $\frac{1}{16}$ of an inch long in the course of ten days, probably it grew in less time than that.

This, and other 'growths,' fell (or grew) off sometime between the beginning and ending of the observed ten days. In May, 1878, another sprig shot up from the very same spot, and remains thereon, probably to this time. [I loaned the stone to the Liverpool Museum, and have not seen it since]. Similar detachments may account for most of the stream-gold at this place, and, probably elsewhere.

Why the stream-gold of this district contains less silver than the electrum *in situ*, I cannot as yet determine; but the fact is so. Sections of some of the water-worn gold show that *cavities* in them are very prevalent. These, as Forbes suggests, are air-cavities, nearly all of them, and will account primarily for the comparatively low specific gravity of stream-gold, as a rule.

The electrum *in situ* hereabout is most unequally distributed.

It is generally thought that native or free gold never occurs uncombined

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with silver, probably this is so. However, free gold frequently contains Fe, Cu, Hg, Pd, Pt, or Ir, or several of them in combination.

The Mawddach stream-gold contains traces of Pt, Ir, and Cu, as well as about 14 per cent of silver.

In some of the pyritous minerals found here, I am certain that the gold does not exist, always, in a metallic state; but that it is frequently combined with Sulphur or Arsenic; or, more or less with both; and occasionally with antimony.

At present, I have detected no tellurides (such as Tetradymite), found so commonly in the Clogau mountain about 5 miles from Tyddyngwladus.

I have several times found spangles of gold at the roots of ferns, growing near the western side of the Mawddach river; and, for more than two miles along the eastern side, a series of shallow pits gave me similar gold at every sinking.

In one place I got several ounces of stream-gold from the margin-dirt.

In the ordinary operation of washing this dirt with the 'batea,' the most 'experienced hand' fails to concentrate the whole of the gold contained in it. There are always mineral admixtures of high specific gravity, such as galena, magnetite, &c.; and, the lighter gold (alluded to above) is always more or less persistent in floating off. So that gold-washing, *per se*, is necessarily attended with great loss of gold (in two ways at least).

Gold-washing in the Mawddach can never be profitable except to 'old hands at it,' on their own account solely, who can conscientiously keep all they may happen to get.

My own trials at it invariably cost me 9d. to 1s. a grain! although the Rhine sand is considered worth washing when containing only 0·00000012 per cent of gold!

The results of two analyses of the Clogau gold, by D. Forbes, are as follows:

Gold	30·69 =	90·16	..	4·86 =	89·83
Silver	3·15 =	9·26	..	0·50 =	9·24
Copper and Iron..	trace =	trace	Fe	trace =	trace
Quartz	0·11 =	0·32	..	0·04 =	0·74
Loss	0·09 =	0·26	..	0·01 =	0·19
	34·04 =	100·00		5·41 =	100·00

Forbes further writes:—

"The metals Au. and Ag. are known to alloy with one another in all proportions, when fused: and, being both monometric in crystallization, are doubtless isometric in their replacements."

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"It is interesting, however, to observe that the above analyses closely agree with the formula $Au^6 Ag$, which, supposing the equivalent of Au. and Ag. to be respectively 196 and 108, would, on calculation, require a per-centage composition of

Gold	90·88
Silver	9·12
	100·00 "*

The most interesting occurrence (from a crystallographical point of view), is what appears to have been a rhomb of chalybite, changed to limonite, &c., around which quartz has commenced to aggregate in a crystalline form.

* The Clogau gold is of a darker color than the Mawddach gold generally, owing to silver and tellurium being replaced by copper. Forbes noticed this himself in a communication to me, and I have often found it so.

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Reviews and Notices.

Chapters on the Mineralogy of Scotland, by Prof. M. Forster-Heddle.

Trans. Royal Soc., Edinburgh, Vol. XXVIII, Chap. IV. Augite, Hornblende and Serpentinous change. Read April 1st, 1878.

IN this elaborate monograph we have another portion of Prof. Heddle's laborious undertaking, which is no less than a complete Mineralogical and geognostic description of Scotland. In the present paper 40 folio pages are devoted to a consideration of Augite from 20 localities, occurring in the following situations, in

Granular limestone
Gneiss.
Diallage Rock.
Diorite ?
Hyperite ? } (The queries are Dr. Heddle's.)
Volcanic Rocks of the Coal formation.
Volcanic Rocks of the Old Red Sandstone.

Dr. Heddle gives a useful comparative table of his analyses (Table 1)

He then goes on to the consideration of some alterations of augite into serpentine, pseudo-augite, pseudo-enstatite, pseudo-diallage, totaigite, and Schiller--spar, devoting 10 pages to this part of the subject and giving seven analyses (Table II.)

Having dealt almost exhaustively with the Augites, Dr. Heddle goes on to describe the hornblende occurrences (23 pages), including Amianthus, Asbestus, Tremolite, Actinolite, Edenite, Pargasite and Nephrite—in

Granular Limestone
Diallage Rock
Serpentine
Hornblendic Gneiss
Diorite

His analyses are given in Table III.

He then devotes 12 pages to the description of a number of alteration products of hornblende, such as hydrous anthophyllite, hydrous asbestus, picrolite, baltimorite, chrysotile, hydrated hornblende &c., and includes in the accompanying table (Table IV) analyses of the minerals known as mountain cork, mountain leather, and mountain silk, which he has since included under his new species pilolite.

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TABLE I.

AUGITE.

	S.G.	$\dot{S}i$	$\dot{A}l_2$	$\dot{F}e_2$	$\dot{F}e$	$\dot{M}n$	$\dot{C}a$	$\dot{M}g$	$\dot{K}_2$	$\dot{N}a_2$	$\dot{H}_2$	Total.
Malacolite												
Shinness, white	3·15	53·06	·19	1·77	·47	·15	23·63	19·29	...	...	1·546	100·12
Totaig, blue	3·2	50·69	·03	·93	...	·07	25·78	18·09	·5	1·43	2·62	100·12
Ben Chourn, white	3·16	51·59	·11	·33	...	...	22·01	19·59	·49	1·01	4·64	99·75
Glen Tilt, white	3·16	53·24	...	2·71	...	·13	22·77	18 86	...	...	2·18	99 89
Glen Muick, blue	3·18	51·	...	1·37	1·59	·38	26·36	17 08	·63	1·12	·26	99·89
Sahlite.												
Ben Chourn	...	54·48	...	...	3·13	·24	22·82	17·58	·44	·79	·42	99·91
Tiree	...	50·54	4·69	4·14	·08	·69	23 59	14·4	·31	·63	1·48	100 51
Eslie	...	49·5	1·96	...	11·06	·4	24·08	10·81	·57	·8	·69	99·86
Coccolite.												
Gruagach	3·05	49·04	6·09	1·89	2·94	·46	23·34	15·12	·82	·79	·17	100 15
Diallage.												
Balta	2·96	50·23	5·84	...	5·22	...	11·23	21·59	1·2	·58	4·17	100·07
Pinbain	3 25	51·77	2·1	...	2·96	·31	22·1	18·46	·63	·58	1·08	99·98
Augite.												
Glen Beg	3·24	54·22	·17	...	6·7	·4	19·57	16 97	·5	·45	·96	99·96
Halival, Rum	3·48	50·54	3·25	1·34	4·42	·23	21·42	17 05	·25	·53	·71	99 83
Craig Buirock	3·28	50·33	4·48	3·92	5·76	·31	17·57	16·62	·19	·89	·38	100 45
Pseudo-Hypersthene.												
Corry-na-creech, green	3·33	53·05	4·82	...	11·39	·08	19·81	11·58	...	...	·63	101 34
Hart o'Corry, bronzy	3·33	51·36	1·66	...	8·97	·33	20·84	16·47	...	.. ...	·54	100·17
Drum-na-Rabm	3·34	51·94	1·32	...	13 9	·25	19·36	13 85	...	Ti ·38	·2	101 25
Loch Scavig	3·32	49·27	·22	2·17	12·15	·38	20 26	14 81	...	...	·72	99·98
Cuchullins (Muir)	3·34	51·35	...	...	33·92	...	1·84	11·09	...	...	·5	98·70
Skye (Haughton)	...	50 8	3·	...	9·61	1·08	19·35	15 06	...	·66	·6	100·16
Cuchullins (Rath)	3·34	51·30	·76	...	13·92	·25	20·15	14·85	...	...	·21	101·44
Augitic Glass.												
Elie	3·33	49·04	9·71	1·25	5·16	·31	16·25	16·88	·31	·79	·3	100 01
John o'Groat's	3·36	46·08	11·39	...	7·92	·46	16·07	15 65	·82	1·06	·38	99·82

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TABLE II.

ALTERATION PRODUCTS OF AUGITE.

CONVERSION INTO SERPENTINE.

	S.G.	$\ddot{Si}$	$\dddot{Al}_2$	$\dddot{Fe}_2$	$\dot{Fe}$	$\dot{Mn}$	$\dot{Ca}$	$\dot{Mg}$	$\dot{K}_2$	$\dot{Na}_2$	$\dot{H}_2$	Total.
Typical Suhlite	...	53·7	...	...	8·	...	24·9	13·4	...	...	...	100·00
Hydration—Loss of $\dot{Ca}$, $\ddot{Si}$—*peroxidation partial.*												
Pseudo Augite, Portsoy	...	37·33	1·13	4·36	4·05	·38	1·2	36·71	·88	·73	13·37	100·14
Pseudo-Enstatite (?) Green hill	2·16	37·78	2·12	5·07	2·1	·76	...	37·01	tr.	tr.	16·07	100·22
Hydration—Loss of $\dot{Ca}$, $\ddot{Si}$—*total peroxidation.*												
Pseudo-Diallage, Portsoy ...	2·62	34·54	1·16	15·2	·33	·28	...	36·38	...	...	12·2	100·09
Pseudo-Enstatite ? Balhammie	...	37·41	...	13·54	·06	·24	·2	34·76	...	...	13·59	99·78
Totaigite, yellow; Totaig ...	...	37·22	·76	...	1·05	·23	5·24	44·97	...	...	10·64	100·11
Do. black	2·87	36·19	·26	·29	2·96	·45	3·27	45·57	·25	·42	10·2	99·97
The same, with no peroxidation.												
Schiller Spar, Black Dog Rock	2·65	38·19	2·18	·07*	8·48	·51	2·91	32·42	1·4	·07	14·03	100·49
Typical Serpentine	...	44·14	...	...	...	...	...	42·97	...	...	12·89	100·00

* $\dddot{Cr}_2$ = ·28

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TABLE III

HORNBLENDE.

	S.G.	$\dot{\dot{S}}i$	$\dot{\dot{A}}l_2$	$\dot{\dot{F}}e_2$	$\dot{F}e$	$\dot{M}n$	$\dot{C}a$	$\dot{M}g$	$\dot{K}_2$	$\dot{N}a_2$	Fl	$\dot{H}_2$	Total.
Amianthus.													
Balta	2·95	56·15	1·54	·39	3·11	·77	11·72	22·46	·19	·69	...	...	99·52
Asbestus.													
Shinness	...	56·85	·23	·48	2·12	·23	12·54	23·92	·44	·54	tr.	2·53	99·87
Portsoy	2·99	56 31	·77	·53	2·32	·15	12·58	23 31	·44	·63	tr.	2·94	99·98
Nephrite.													
Balta	2·96	55·73	·05	...	5·2	·01	13·24	22·7	·14	1·12	...	...	100·62
Schistose.													
Leegarth, Fetlar	2·95	56·92	·22	...	4·65	·08	12·32	22·08	tr.	tr.	...	3·4	99·66
Tremolite.													
Shinness	2·96	56·15	·86	1·62	·72	·07	13·31	24·14	·44	·21	tr.	2·5	100·01
Glen Urquhart...	...	57·31	6·68	1·08	3·23	·31	12·36	16·62	...	...	tr.	2·5	100·08
Actynolite.													
Hillswick	...	55·	1·51	·99	3·46	·31	10·38	23·31	1·12	1·1	...	2·9	100·07
Edenite.													
Urquhart, green	...	50·31	8·54	·12	2·76	·08	11·63	20·77	·5	1·16	none	4·13	99·99
Do. black	...	51·31	2·21	·16	7·66	·49	11·17	20 87	2·2	·46	...	2·12	99·65
Pargasite.													
Errins...	...	52·69	2·56	4·09	9·77	·23	11·42	15·77	·57	·69	...	2·13	99·91
Hornblende.													
Balta	3·11	45·87	8·78	...	14·15	·13	9·82	14·4	·82	1·43	...	2·3	97 7
Fetlar	3·09	41·63	11·63	1·85	8·95	·31	9·25	18·51	·63	1·22	...	...	99·37
Portsoy	3·25	52 07	2·57	...	9·72	tr.	19·05	14·41	·75	·57	...	·85	99·99
Glen-bucket	3·22	45·	9·41	1·55	16·76	·33	11·24	11·19	1 36	1·66	...	1·34	99·85
Durness	...	51·46	2 97	2·45	9·66	1·08	20·07	10·46	·68	1.31	...	·68	100 83
Elie	3 37	40·38	19·01	2·12	7·28	·46	11·54	17·5	...	...	...	1·17	99·48

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TABLE IV. *ALTERATION PRODUCTS OF HORNBLENDE.*

	S.G.	$\ddot{Si}$	$\dddot{Al}_2$	$\dddot{Fe}_2$	$\dot{Fe}$	$\dot{Mn}$	$\dot{Ca}$	$\dot{Mg}$	$\dot{K}_2$	$\dot{Na}_2$	$\dot{H}_2$	Total.
Hydration, Loss of Ca, *peroxidation*												
Hydrated Hornblende, Green Hill ...	3·01	50·92	1·89	9·48	2·09	·31	8·65	21·58	·34	·43	4·54	100·17
Hydrous Anthophyllite, Scoorie	2·92	45·51	6·39	...	14·29	...	4·44	22·14	tr.	tr.	6·72	99·44
Mountain Cork, Portsoy	...	51·43	7·52	2·06	2·49	1·3	·58	9·35	...	...	25·04	99·76
Ditto Lead Hills	...	51·45	7·98	·97	3·29	1·49	1·97	10·15	...	...	21·7	99·
Mountain Leather, Tod Head	...	52·48	6·33	·6	2·11	2·88	1·34	11·95	...	...	21·7	99·4
Mountain Silk, Partan Craig	2·11	54·37	11·27	·21	1·09	·33	·98	9·49	...	...	22·41	100·16
Hydration, Loss of Ca *and bases—passage into Serpentine.*												
Picrolite, Balta...	2·69	50·19	2·1	...	4·39	·01	5·07	29·23	...	·74	8·5	100·23
Do. Serpentinous, Balta	2·63	50·08	1·88	...	6·09	·23	·86	31·57	...	·34	9·3	100·34
Above, with removal of Silica.												
Hydrous Anthophyllite, Urquhart ...	2·81	47·72	3·84	·18	5·74	·16	5·64	28·75	·19	·26	7·65	100·12
Hydrous Asbestus, Portsoy	2·39	46·92	·63	·01	1·67	·77	9·91	25·85	·57	·58	12·84	99·75
Picrolite, Fethaland	2·65	42·93	1·85	5·1	...	·42	·8	36·19	·81	·37	11·5	99·97
Hydrous Anthophyllite, Ayrshire ...	2·81	39·75	·49	5·3	4·11	·23	6·27	26·25	·76	·11	16·83	100·1
Baltimorite, Killin	2·63	41·47	...	4·01	4·88	·26	...	37·14	...	...	12·5	100·2
Chrysotile, Fetlar	...	39·73	·1	...	2·92	...	...	41·61	...	...	15·66	100·02

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In discussing the whole series of analyses, especially of the altered minerals, and of the method of serpentinous change, Dr. Heddle observes—

"These results demonstrate that the process of change consisted, in progressive order.

First, in a direct increment of the water.

Second, in a decrement of the lime.

Third, in a gradually increased decrement of the iron.

Fourth, in a decrement of the silica.

In same situations, however, there is no decrement in the iron, but a peroxidation thereof.

What the rationale of the change under the *first* of these heads may be, I could not, in the circumstances of so small an amount of matter to found on, attempt to show.

The circumstances under which some at least of the other changes may be effected we do know; and our knowledge thereof may be grouped under certain heads.

The leading summary of our knowledge may be stated thus:—

The primary agent of change is meteoric water, holding carbonic acid and oxygen in solution.

The secondary agent is spring water, holding less oxygen, more carbonic acid, and certain salts in solution.

The third agent is these same waters, sinking downward or rising upward, but now holding more complex salts—the products of the first operation of the waters themselves,—these salts being the agents of a second set, perhaps an endless cycle of changes, generally more potent than the originals.

As regards the substances operated on, we know that those most easily attacked are carbonates and silicates of the alkalies, the waters thus becoming charged with most potent graving tools.

Next we have silicates which contain lime, protoxides of iron, and of manganese.

Lastly, we know that silicates of alumina and magnesia are the most stable of all; for carbonated water has no action upon silicate of alumina, and but a slight one on silicate of magnesia.

In virtue of the above,—from compound silicates carbonated waters will abstract the silicates of lime, iron, and manganese; leaving the silicates of magnesia and alumina as residues.

In virtue of the above,—the rock masses which we find in nature to be least prone to decomposition, are either immediately silicates of alumina

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and magnesia, or they are such as have originated from the alteration of the less stable silicates. Such are—steatite, talc, silicate of alumina, clay, kaolin, and sand itself—among simple silicates; and mica, chlorite, serpentine, asbestus, and mountain leather—among compound ones.

These, however subject they may be to more complex changes induced by saline or alkaline waters, are no longer liable to further alteration through the operation of atmospheric agents—such as oxygen, carbonic acid, and water.

Thus it is, then, that serpentine *asserts itself* wherever occurring; protruding as lines of rugged eminences,—fitter types of the attribute assigned to the "everlasting hills" than the lordlier granitic masses around it; thus it is that the mica crystal, which, torn from that granite, and mechanically comminuted but intrinsically unchanged, has served its purpose of giving continuity and sparkle to sandstone of newer and still newer epoch, glitters yet untarnished mid the sands of the sea-shore; and thus it is that these sands themselves, buffetted by the waves of Cambrian, and Old Red, and Coal Measure, and Permian, and it may be still more recent epochs, amid many surrounding changes have known none, but atomies though they be, seem quite large enough and hard enough again to complete a like extensive cycle.

Thus it is that the clay which, as impure kaolin, the rain drop has gouged out of the felspar of that granite, which, soft as mud, gives way to everything, but can be changed by nothing,—is seized upon by man to be fashioned into a structure, harder, less compressible, more durable than stone itself.

Thus, then, the mere passage of a current of carbonated water over minerals containing, or rock containing lime, iron, and silica, is sufficient to sweep these substances in solution out of the rock, and to do so, moreover, with great rapidity.

It was Bischof who first clearly pointed the potency of carbonated waters in effecting decomposition of rocks containing the substances above noted as soluble therein; and its absolute want of power to remove magnesia from them on account of the insolubility of silicate of magnesia in carbonated waters or even in carbonated alkalies, supposing these to be formed as a first step in such a process.

Hence the direct and unfailing action of such waters upon augitic rocks must be their conversion into serpentine.

It has been shown that inasmuch as carbonic acid does not combine with alumina it can have no power to remove alumina; and so a serpentine formed by the alteration of an aluminous mineral must be a more or less aluminous serpentine. And inasmuch as it is in hornblende and not in

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augite that alumina replaces silica, we may if we find, on analysis that a serpentine is notably aluminous, be able to say that it was formed by the transmutation of diorite or other hornblendic rock.

Again, inasmuch as carbonic acid does not combine with the peroxide of iron, if that substance is either present, or once formed in a mineral, it cannot be removed by such a process; and so it is that we have the iron in these serpentinous products unremoved if it be thrown into the state of peroxide.

Its retention as such may even aid us in determining the depth at which the transmutation took place.

If the change was effected near the surface, we know that the transmuting water was aerial,—"meteoric water," as it has been called. Each gallon of such water holds in solution 2 cubic inches of oxygen and 1 of carbonic acid. This water, holding so small a charge of carbonic acid, could only effect the transformation with extreme slowness. We have seen that the lime was removed in the first place; if the quantity of acid did not suffice to remove both lime and iron, during the time that that acid was engaged in taking up the lime, the oxygen in solution would simultaneously be engaged in peroxidising the iron.

So we would be entitled to hold that serpentines with red or brown colours, and such as retained iron as peroxide, had been formed near the surface. So can we explain, also the ferruginous crust which is so characteristic of most serpentines at their outcrop.

Spring waters, again, much more highly charged with carbonic acid, but not carrying so large a supply of oxygen, would effect the change more rapidly, and sweep away, more or less, perhaps all of the iron as protocarbonate, leaving only residual traces of protosilicate, which impart the green coloration.

We have at Portsoy the most direct evidence conceivable of the conversion of diallagic rock into serpentine, in the fact that one end of the stratum still remains as gabbro; and in immediate contact with it we have limestone, here very siliceous. Now, the frequent association of thin beds of limestones with serpentine supplies very direct evidence of the conversion of hornblendic and augitic rocks into serpentine. In that fact we have a ready answer to the question, "What becomes of the carbonate of lime necessarily formed during such an alterative process as the above?"

I will not say that limestone is always to be found in such association; we do not always find limestones even where we have indubitable evidence that they once existed; for here the very thing that makes can unmake, or sweep away. The carbonate of lime thus fashioned out of the mol-

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forms a belt beneath the residual serpentine, thicker or thinner in accordance with the original thickness of the stratum of transformed rock; also thicker or thinner according to whether that rock was augitic or hornblendic; for the former can supply considerably more lime than the latter. This calcareous belt must lie beneath the parent rock, sealed against any great amount of further change, unless or until upheaval or denudation expose it to meteoric influences. *Then* water, flowing either downward or upward, may—nay, in time must—sweep it away in solution, leaving lime-sink, or collapsed-void to evidence its former existence. But if the limestones, so frequently associated with serpentines, are thus to be assigned to the decomposition of the rock which yielded these serpentines, we have a crucial test of the soundness of the theory of the change, in the inquiry as to whether *unchanged* gabbro, or other such rocks occur in contact with lime.

That it never does, I will not say; but in glancing at a sketch geological map which I have constructed of the district where these rocks occur, I find, as regards the great belt of diorite and diallagic rock which sweeps up central Scotland, that where either the limestone appears in contact with it, or a "wash-out" discloses its former existence, there the rock is serpentine; where it appears as unaltered rock there is no lime.

I find, moreover, that wherever the association can be observed, the lime invariably is beneath the serpentine. So it is with the loch of Cliff lime and the serpentine of Unst; both of the lime and serpentine beds at Polmally; both of the lime and serpentine beds at Portsoy; at Limehillock; Tombreck; the Green Hill of Strathdon; and Beauty Hill; and in enumerating these I have named all the most important masses in the country.

The evidence of our transmuted minerals thus goes a long way to prove serpentine to be a metamorphic, and not an igneous, rock, whether the chemical process proposed in explanation of the *modus operandi* of the change be or be not considered satisfactory.

But there are occurrences of serpentinous matter differently circumstanced, where the above explanation can by no means suffice.

By the dissolving out of the lime from a stratum either of gabbro or of labradoric diorite, we would obtain a great mass of limestone, it is true; but that mass, relatively to the simultaneously formed serpentine, should be comparatively small.

The hornblende of Portsoy would yield equal to about 34 per cent. of carbonate of lime—its labradorite would yield about 20 per cent.; and, as in the diorite rock, the hornblende is to the labradorite in about the proportion of 2 to 1, this rock as a whole would yield about 29 per cent.

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of its original bulk; of which, however, there remains still 34 per cent., for 13 of the 29 consist of direct addition of carbonic acid. Here, then, we have a rock yielding by its metamorpheses about one-third of its original bulk of carbonate of lime.

But, in what are called the serpentinous marbles, quite a different state of matters exists. These marbles I know from one part of the bed in Tiree; from Loch Bhalumais, in Lewis; Rodal, in Harris; Dalnein, in Strathdon; Glen Elg; Glen Tilt, and some neighbouring localities. It is of these only I am entitled to speak.

In all, the appearance is the same,—granular imbedded particles of serpentine, from the size of a shot to that of a bean, sparsely sprinkled throughout a great mass of lime, in an amount which is altogether quite trifling

Unhesitatingly I say that these granulars are, one and all, pseudomorphs of pre-existent crystals of augite. That mineral may be seen unchanged and changing in the Tiree marble. In Glen Elg and other localities the pseudomorphic forms are so perfect that the crystalline form of the augite is indubitable.

These trifling specks could never have been the origin of a lime stratum tens of feet in thickness.

I would suggest the following explanation of the serpentinous formation of these pseudomorphs,—which had palpably pre-existed as augitic crystals imbedded in lime.

It is well known that when silica or silicates are heated along with carbonate of lime, there is, in the first instance, a disengagement of carbonic acid and a formation of silicate of lime; or, in the presence of other bases, of more complex silicates. Bischof found this decomposition to take place unfailingly even at the temperature of boiling water. No great depth in the earth's crust would suffice for the attainment of such a temperature. Thus at the point of contact of the lime with the including rock, and also with inclosed siliceous minerals, would there be disengaged the very acid which we have already seen to be the active agent in serpentinous change; and thus also would there be formed new silicates, such as Wollastonite, silicate of lime, and tremolite, which, in fact, are found associated with the pseudomorphs of the serpentinous marbles.

In the outset I directed attention to the fact that serpentines were occasionally formed by the transmutation of such rocks as diallage and diorite *as a whole*,—*i.e.* that the labradoric as well as the augitic ingredient had suffered conversion. The analyses afford one if not two instances of such conversion, and I now instance another which may be a case in point.

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Beauty Hill, to the north of Aberdeen, is composed of serpentine, and in small quarrys on its north-east side it will be seen to be as distinctly bedded a rock as any recognised sedimentary deposit.

On its eastern slope some masses of gabbro protrude through the sward of a field. This gabbro is, for the most part, unaltered. It consists of dark somewhat granular crystals, apparently of augite, of the size of large shot, which are imbedded, singly or separately, in a waxy-looking massive labradorite.

In this rock a vein of a pale sap-green mineral was found by Professor Nicol and myself. This was set down by my friend as precious serpentine; to me it appeared somewhat too hard for this, as it cut with less ease than slate-pencil. It was translucent, tough, and had a specific gravity of 2·59.

On analysis it afforded—

Silica	34·731
Alumina	12·444
Ferrous Oxide	2·684
Manganous Oxide	1·17
Lime	1·595
Magnesia	34·098
Water	13·1
	99·822

Now this is precisely the composition of the massive variety of penninite which, from its resemblance to serpentine, has received the name of pseudophite. But it may also be regarded as a highly aluminous serpentine; for if that earth be abstracted the residue is just serpentine. The point of interest which attaches to this substance is, that although it formed a true exfiltration vein in the rock; if the rock in contact with the vein be examined, *the waxy labradorite is also seen to pass, within a space of about an inch, into this mineral by insensible gradation.* So it matters not whether it, in a systematic arrangement, be consistently classed with penninite or not, it is here unquestionably a transmutation product, the result of a serpentin*ous* change of the labradorite.

The *modus operandi* of the change of felspar into serpentine is much more subtle than that of the conversion of augite, and also, it must be said, much less certain. As labradorite contains much alumina, and no magnesia, we have in *its* serpentinous change, to account for the removal of alumina and the direct insertion of magnesia. The term "magnesian process" may with perfect fitness be applied to such a change.

Such an action as that above shown to suffice for the transmutation of augites could not in any degree effect a similar change in labradorite;

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carbonated waters do not affect silicate of alumina, and carbonated waters cannot directly purvey magnesia.

It is true that immediately over the bed of serpentine at Portsoy which evidenced such a change, there is a washed out bed of *something*, and it might be argued that that something had been dolomitic limestone; which would yield bicarbonate of magnesia to waters passing through it;—which bicarbonate of magnesia, by a recognised interchange with silicate of lime, would yield silicate of magnesia. To such a view it has to be replied, first, that there is no evidence that the removed stratum was limestone,—the rock immediately beyond the void is a perfectly unaltered diorite, which therefore could not have supplied any lime;—secondly, that in Scotland at least, the limestones associated with serpentine are not dolomitic; and this because, according to the opposite view, the magnesia is retained in the resultant serpentine;—and lastly, that there is no provision, according to such a view, for the removal of the alumina.

For aid in the explanation, we must ascertain what are the circumstances in which silicate of alumina can either be decomposed or dissolved; and what those in which silicate of magnesia can in any way be introduced; we will then be in a position to say whether any of the said circumstances, in the case in question obtain.

Silicate of alumina can be decomposed by chloride of magnesium or sulphate of magnesium in solution,—silicate of magnesia being formed.

Silicate of magnesia, again, is also formed by the decomposition of bicarbonate of magnesia, by silicate of lime, or by silicates of the alkalies.

Now the two first of these salts are present in river water, more largely in spring water, and most largely in sea water; while bicarbonate of magnesia is very frequently present in spring water. Though it is unnecessary to call in the operation of sea water, in the presence of the fact that the waters which permeate all rocks are themselves charged with these potent agents of perpetual change, still, seeing that the altered rocks in question have been beneath the sea, and that their inmost pores would then be more urgently saturated by hydrostatic pressure, it may be very fittingly argued that diallagic rocks which have their felspar as well as their augite converted into serpentine, suffered the alteration during an epoch of marine submergence.

Bischof writes: "It would be very illogical to suppose that the calcareous and magnesian salts dissolved in sea water do not take part in chemical alteration, when it is so manifest that alteration is effected by these salts dissolved in much smaller quantity in the water percolating through rocks. It would be inconsistent with the relation of mutual compensation perceivable in all natural phenomena to suppose that saline

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substances were continually carried into the sea, without being consumed in the formation of new substances." To apply this to the present case, there would seem to be no readier way of accounting for the abstraction of the vast quantities of magnesian salt present in the sea, and constantly being added to it, than to use it up, so to speak, in the formation of serpentine. How else abstract so soluble a salt as chloride of magnesium? Its extreme solubility and deliquescence would negative its being abstracted through the direct formation of minerals; but, in virtue of the above interchange, lime salts replace it in the ocean, to be continuously removed in turn by crustaceans, mollusks, and coral insects.

Serpentines, as a rule, are denser, more solid,—give fewer and feebler evidences of being the result of change effected upon pre-existent rocks, when examined *in their depths* than on the exterior. Without entering upon the many and complex reactions which take place as secondary results of the interchanges already noticed, it may be sufficient to show that the products of surface change, as they percolate through the deeper portions of a rock, may effect a somewhat dissimilar change therein, and may also, in their passage through these rocks, plug up their pores.

Silicate of lime, formed by the action of meteoric water in the superficial portions of a rock, and meeting with magnesian salts within, would by interchange supply serpentinous matter in the solid form to the more porous portions of the deeper-seated beds, to render the whole mass more uniform in structure, while it might also therey be diversified in colour.

When we remember that the decomposition of both augite and labradorite is effected through the operation of what may be called the ordinary agents of exposure—carbonic acid, oxygen, and water—but that, in virtue of their difference in composition, the nature and rate of the decomposition varies, it is easy to explain how it is that the crystals of labradorite are protuberant from the general mass of the augite at Lendalfoot, while at Pinbain the augitic crystals stand in high relief above the felspar in that wave-washed situation.

Augite, containing iron in the state of protoxide, most prone to higher oxidation, rapidly and readily gives way when subjected alike to aërial exposure, where oxygen, carbonic acid, and water are free to operate upon it. Labradorite, containing little or no protoxide, is subject to the operation of the two last only, and so, in the air, is more enduring. When plunged beneath water, however, the oxygen is in great part shut off from the augite, which is thus protected; while here, the labradorite is subjected to the attack of water upon its alkaline silicates, suffering thereby rapid degradation."

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After some pages of descriptive Geognosy, Dr. Heddle discusses the mutual associations of hornblende and augite.

"Turning our attention next to the modes of occurrence and lithological associations of the unaltered varities of augite and hornblende, the first direction our inquiry must take is as regards any evidence the analyses may afford, bearing upon the union of the two species into one.

It may be at once conceded that this question cannot be decided by any merely chemical evidence; the wide range of composition, hardly referable to anything closer than a general formula in either mineral, precludes such an hope. The little information that we do obtain tends in the direction of the separation of the two; it consists in this, that in what may be designated as "recognised individuals" of the hornblendic type we have here and again a distinct replacement of silica by alumina; and this we have not in recognised individuals of the augitic type.

Passing from this to the lithological information, we find that a consideration of the records above made by no means tends to strengthen certain of the lines of demarcation which have been drawn between them.

Put in a general form, two of these lines are thus defined: "These two minerals occur in distinct geognostic positions. Hornblende in rocks containing quartz or free silica, and mostly with minerals that are neutral compounds of silica, as orthoclase and albite. Augite in rocks that do not contain free silica, and mostly with minerals that are not neutral silicates, as labradorite, olivine, and leucite.

"Hence, there are two distinct series of igneous rocks; the hornblende series, including granite, syenite, diorite, &c.; and the augite series, or hypersthene rock, gabbro, dolerite, &c.

"In some rare instances these two minerals have been found together, either regularly conjoined or in distinct conditions."*

Here we have it clearly laid down that two "distinct series of igneous rocks" are established on the specific distinction between the two minerals; and secondly, that one argument for these minerals being themselves distinct is to be drawn from the fact that they are associated in but "rare instances."

It would appear at first sight to be an easy matter to enter at least upon the consideration of questions couched in language so precise as the above; but it proves to be not altogether so.

* Nicol's "Manual of Mineralogy," p. 208. An epitome of the views of Gustav Rose

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We have it *first* laid down here that hornblende occurs in rocks with free silica, and along with orthoclase and albite.

Secondly, that augite occurs in rocks devoid of free silica, and,—in contradistinction to hornblende,—along with labradorite, olivine, &c.

Thirdly, that the hornblendic series of rocks,—granite, syenite, diorite,—are "distinct" from the augitic series,—hypersthene rock, gabbro, dolerite, &c.

Fourthly, that the two minerals, on the distinctiveness of which the above separations have been made, occur together in rare instances."

Dr. Heddle then gives examples shewing that postulate No. 1, is contradicted almost everywhere in Scotland, and postulate 3 and 4, very frequently, while postulate 2 is almost always true. He adds, "My own opinion is, that through insensible gradations—intermediate varieties —augitic and hornblendic rocks pass into one another more frequently than is imagined. The two minerals also, in certain circumstances, are so very similar that I do not believe that any mode of discrimination which can be applied in the field, or any more expeditious than the reflective goneometer, can serve to determine them; so that defective nomenclature may have been the cause of the drawing of too sharp a line of demarcation between the rocks which contain them."

The author concludes this most important contribution to Mineralogical literature as follows.

"One other point calls for brief notice,—the question as to augite being a volcanic or fusion-form of hornblende. It will be seen above that both of the minerals occur in granular limestones; these afford very distinct evidence of the operation of great heat.

Again, it will be observed that both occur together in the basalts and dykes of Elie and Kinkell; in these the one mineral—the augite —has undergone fusion; while the other—*the more fusible*—appears unchanged. This circumstance becomes a strong argument in favour of the latter having been formed *in situ*,—*i.e.*, after the eruption and cooling of the containing rock,—an exfiltration product in fact.

Here it may be the case that the fused augite has at one time been formed from hornblende, but the two could not here have been erupted together; so that no direct evidence is to be gleaned from this apparent paragenesis in space, which palpably was not a paragenesis in time."

The monograph will well repay every mineralogist and geologist who shall study it in its entirety.

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THE WHITE MINERAL OF THE FOSSIL PLANTS, FROM THE TARENTAISE (*Min. und Pet. Mitt, Tschermak, Band II, p.* 191).—The peculiar silver-like shining covering of most of the plant fossils included in the carboniferous shale of Westphalia has not yet been carefully investigated, and its similarity to the substance forming the Graptolite petrifactions, first described by Gümbel and more extensively by Köbell, induced the present investigation—a peculiarly rich piece of the substance offered the opportunity of making an exact analysis.

This delicately scaly mineral is, like that associated with the Graptolites, not distinctly crystallised, but found only in little thin scaly leaves: these are fissile, somewhat elastic, flexible, soft, white, of a pearly lustre; fatty, talc-like to the feeling. Hardness=1, Sp. Gr.=2·8. Before the blow-pipe in melting exfoliates in a cauliflower-like mass similar to Pyrophyllite, and with cobalt solution gives a deep-blue color. In test tube yields water; not entirely dissolved by sulphuric acid. The purest material chosen with the greatest care under the lens gave the following analysis (A); there are also given analyses of the clay-slate of the Tarentaise (B), of Gümbellite (Köbell) (C), and lastly, of an additional Graptolitic mineral from Gräfenthal in Thuringer Wald (D).

CONSTITUENT PARTS.	A	B	C	D
Silica...	49·710	56·80	50·52	52·50
Titanic Acid	1·035	6·70	...	1·00
Alumina	28·620	25·45	31·04	29·50
Oxide of Iron	2·688	3·05	3·00	3·00
Oxide of Manganese	trace	...	...	...
Lime	trace	trace	...	...
Magnesia	1·600	1·03	1·88	1·16
Potash	6·803	4·20	3·18	5·06
Soda..	2·208	1·36	...	
Water and Ash	7·384	8·00	7·00	7·75
	100·048	100·59	96·62	100·47

From the analysis the substance therefore approaches pyrophyllite. The similarity also of the analysis of the clay-slate in which the plant remains and the whole mineral lie imbedded, appears to show that the substance contained in the bituminous shale, during a process favourable for the formation of the mineral is forced into the cavities originated by the carbonisation of the substance of the plant. In fact, in sections perpendicular to the cleavage plane, it is observed that the slate consists of transparent, extremely thin layers strongly affected by polarised light which appear as minute bands, or bands with lens like thickenings: with them alternate others wanting in

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transparency, from masses of carbon or dust-like matting which are less distinctly doubly refracting. The chief mass of the slate consists accordingly of a substance very similar to that of the petrified plants. In sections parallel to the cleavage plane, they exhibit defined circumscribed layers clear as water, and doubly refracting, alternating with carbonaceous borderings and dust-like, cloudy, non-transparent spots, with indefinite optical relations. Of the transparent parts only a small portion is not doubly refracting. What is particularly interesting is the abundance of long, not exactly straight black needles resembling the Trichetes observed in clay-slate, roof-slate, and Phyllite. In addition, small transparent crystals show themselves, which exhibit bright colours in polarised light, and appear also to belong to the white mineral.

T. A.

URISITE—A. FRENZEL (*Min. und Petr: Mitt*; *Tschermak*, 1879, p. 133.) In an article on the "Minerals of the Caucasus," A. Frenzel draws attention to a new mineral named by him Urisite, and having the following peculiarities: color from citron to pomegranate-yellow; streak, ochre-yellow; soft; sp. gr. 2·22. Found in nodules and pulverulent, nodules yield to pressure by the finger, when a feeble lustre accompanied by a faint metallic glance is observed, dependent upon minute crystalline surfaces.

Urisite consists entirely of minute rhombic crystals such as Breithaupt has already observed in the similar mineral Raimondite. The crystals appear under the microscope broadly columnar; sharp-angled and well-formed, exhibiting frequently by combination $\infty\breve{P}\infty$. $\infty\bar{P}\infty$. ∞P. $\bar{P}\infty$. P. OP. The basal plane is occasionally absent: sometimes at one pole the basal surface is very great, at the other small or apparently not developed; so that the crystals then appear hemimorphous. Beneath the microscope the Urisite crystals appear transparent; the mineral has, after the deduction of 3 p.c. of an insoluble residue, the following composition:—Sulphuric Acid, 42·08; Ferric Oxide, 21·28; Soda, 16·50; Water, 19·80.

Sulphur is present in small quantities; and traces of carbonate of lime and talc exist. The ascertained composition corresponds to the atomic relation Fe_2O_3, 2 Na_2O, 4 SO_3, 8 H_2O, and this formula to

Fe_2O_3	160	21·39
2 Na_2O	124	16·58
4 SO_3	320	42·78
8 H_2O	144	19·25
	748	100·00

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The result of the analysis thus corresponds almost exactly to the calculated composition, and Urisite stands near to Bartholomite.

T. A.

MILARITE,—E. LUDWIG (*Tschermak, Min. und Pet. Mitt.*, 1877).—This mineral has only been twice analysed, but with such varying results that a repetition of the investigation was absolutely necessary, and was rendered possible by the author having received about 2 Grams of a picked, well-formed, and perfectly transparent crystal of this rare mineral.

Milarite gives off water on being heated and continues to do so when the finely powdered mineral is heated in the platinum crucible for half-an-hour in the Bunsen flame, the mass becoming only slightly ash-like. In the hot blast of the blowpipe flame no marked diminution of weight is observed after heating, but a perfect fusion occurs, and if after this it is allowed to cool by degrees a transparent colorless glass-like mass is obtained not perfectly soluble in hydrochloric acid. Concentrated fluoric acid in the hot water bath dissolves the finely powdered Milarite in a short time.

A quantitive analysis gave the following results :—

	I.	II.	III.	AVERAGE.	CALCULATED.
Silica	71·85	..	71·88	71·81	72·66
Alumina	10·74	..	10·61	10·67	10·39
Lime	11·58	..	11·71	11·65	11·30
Magnesia ..	trace	..	..	trace	..
Potash	..	4·86	..	4·86	4·74
Soda	..	trace	..	trace	..
Water	1·35	..	1·38	1·36	0·91
				100·35	100·00

The calculated values correspond to the formula $HK, Ca_2, Al_2, Si_{12}, O_{30}$.

These results agree closely with those of Finkener, who probably did not possess an entirely pure mineral (the deviations being explicable by a small admixture of felspar.)

The crystalline form of Milarite as known to Kengott was described as an hexagonal combination of a prism and a pyramid of the second order. According to Tschermak's investigations it must now be referred to the rhombic system, the crystals being penetrative twins, similar to those of Chrysoberyl and Aragonite.

T. A.

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ACCIDENTAL COLORS OF ZEOLITES.—WEBSKY (*Berlin*)—*Zeitschrift fur Kryst. und Min., B. II, P.* 517.)—In addition to the red coloring matter of the Zeolites of Dumbarton and of Fassa, colors occur which are dependent on organic substances, as for example those of the Desmin and Heulandite in the magnetic iron veins of Arendal, in which also asphalt is met with. To this second class also belong the colors of the Zeolite lately discovered in the drusy cavities of the granite of Gräben at Striegau. At this locality Desmin of a pale leather-brown colour is of frequent occurrence. Chabazite, of a chestnut-brown hue, passing into orange-red frequently in the centre of the purer crystals is much rarer. The latter on heating becomes dark and a small quantity of tar-like substance distils off. The rare Heulandite of this locality is bright citron-yellow, whilst that of the rarely found laumontite is colorless. It appears, therefore, these chemical combinations though so similar in composition, possess very different capabilities for the reception of coloring organic matters. As to the origin of the latter, in this instance, it may be explained by the assumption that the Striegau granite is a metamorphic formation.

T. A.

APOPHYLLITE FROM HIMMELSFÜRST MINE, NEAR FREIBERG.—(*Neues Jahrbuch für Mineralogie*, 1879.)—Prof. Weisbach has lately described the occurrence of apophyllite near Freiberg. Zeolites, as is well known, have frequently been found in mineral veins, and especially silver lodes; for instance, at Andreasberg, Kongsberg, and Guanajuate; but none had been found at Freiberg till recently. In December last, at a depth of more than 500 yards, in driving a level, a little cavity or "vugh" was met with in the gneiss immediately adjoining a silver lode. The "vugh" contained crystals of quartz, and on these were crystals of calcite, surmounted by apophyllite.

C. L. N. F.

Obituary.

BERNHARD VON COTTA.—This distinguished geologist and mineralogist died at Freiberg on the 14th September, aged 71. He was elected a corresponding member of this Society on the 2nd June in the present year. His memory is dear to many of our members who have had the advantage of studying under him at Freiberg.

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XVII.—*The Geognosy and Mineralogy of Scotland.*

By Professor Heddle.

THE ORKNEY ISLANDS.

Part I.

JAMESON tells us that it took him six weeks to survey Orkney geologically, and that the journey was the most uninteresting he ever made; his journal, indeed, is little more than a record of disappointments. Jameson's statement, so far from concealing, disclosed an indubitable fact, that to relieve the tedium of the hammer through weeks of wandering, some impulse,—some attraction of a different nature must be associated with it. Jameson himself showed that such attraction was present with him, though he seems to have put a restraint upon himself as regards the alluding to it.

In his preface he says—"I hope that I have not been insensible to the emotions which naturally arise from the retired and striking scenes which often burst upon me in the unfrequented tracks which my pursuits led me to explore:"—and though he expressly states that it is not his "purpose to obtrude these things," still "these things"—the stimulus of the grandeur of nature—the secrets of nature acting as the loadstone to his desire to unfold their workings,—these things do occasionally break through even his reserve, but not obtrusively.

That the impulse necessary for alleviating the burden of the hammer should have been comparatively dormant if Jameson had visited Orkney after having left Shetland might not be surprising. In comparison

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with that land of many diverse strata, the unvarying monotony of the glaciated contours, and half-submerged sandbanks of an Old Red Sandstone country must have proved tame indeed; but there can be little doubt that if Jameson had made his survey of *Caithness* anteriorly to that of Orkney, his expressions of discontent and disappointment would have been so thoroughly expended on that more monotonous and most mineralogically-barren land, that a feeling of relief if not of interest would have been experienced while Orkney was being surveyed.

It is sufficiently significant in this connection to notice that, while the survey of Orkney occupies seventeen pages of his work, Caithness is dismissed in six.*

But while admitting that Orkney is to the mere mineralogist a comparatively uninteresting country, it must be allowed that now that mineralogy is marching hand in hand with chemistry as the handmaid of geology, Orkney comes to be far from devoid of interest.

Geikie writes:—"In quitting Orkney I would refer to the many admirable sections exposed along the mural sea-cliffs of that storm-swept group of islands, and to the endless instructive lessons furnished by them on stratification, jointing, and other elementary questions in physical geology, as well as on the progress of weathering, its relations to rock structure, and the proportional share taken in it by the sea and the atmosphere."

The Orkneys are composed almost solely of rocks, till lately assigned wholly to Old Red Sandstone age.

This formation, though of the highest interest as regards its fossil ichthyology, is usually singularly barren in those rock features which aid in elucidating the changes through which the crust of the earth has been formed, and by which it has been affected; while it is also markedly barren as a field for the researches of the mineralogist.

The monotony which attaches to a single formation is, however, relieved somewhat by the occurrence of a narrow strip of older rocks in the west of the county;—by the unmistakable evidence afforded in one island that these Old Red Sandstones are not here to be assigned to *one* geologic epoch;—and by a great development of the system of trap-dykes, which occurs so markedly along our western coasts,—that namely of tertiary age and which has a W. and E., or W.N.W. and E.S.E strike.

* Jameson quits the Orkney Islands with a warm acknowledgement of a hospitality which was "confined to them"—a hospitality which "seemed to look for no return;" while of Caithness he has no hospitality to record; he designates it a "mean looking country, the tedious unformity of the bleak scene being only varied by the appearance of old ruinous castles, or recluse gentlemen's seats situated amid brown desert heaths." We find him say in one place—"we could get little to satisfy our craving hunger."

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These rocks are considered by Geikie to have been laid down in the same basin as those of Shetland; and, so far as the sandstones of the west side of Shetland are concerned, this is doubtless true.

The sandstone rocks of Orkney however differ widely in lithological aspect from those of Shetland.

The grits and conglomerates, which were there seen in immediate contact with the older rocks, here find no place. If the deposited sands have been laid down in the same oceanic lake, the beds here seen occupy a much higher zone. Except at one spot where local circumstances alone have produced it, no bed of heterogenous or coarse-grained material, or containing recognisable fragments of an older rock, is to be seen. The beds which would appear to be the deepest-seated, are those which consist of the most highly-comminuted materials; argillaceous and slimy-looking silts and blue flags—sometimes glimmering from minutely interspersed mica, or "bituminous" from having been the recipients of the products of the death and decay which were taking place in supernatant waters which teemed with animal life*

The general dip to these beds is to the west; they are frequently however not far removed from the horizontal; undulating folds also run across the islands from east to west; and on both of these extremes the dip is, in the north of the county, at least towards the centre.

Up that centre, moreover, there runs a well marked trough which bears about N.E. to S.W., and the upper beds of this trough are markedly different from the rocks of the other parts of the islands.

This trough is in many parts submerged, but the beds which define it are well seen in their eastern limits, though to a much inferior extent in the western.

These beds consist of loose arenaceous freestones, with silicous granules sometimes so coarse as almost to entitle them to the designation of grits.

*Jameson divides the beds into sandstone, sandstone-flag, schistose-clay, and indurated clay. Jameson's sandstone-flag he defines as schistose sandstone with a argillaceous cement.

His "schistose-clay" he thus defines.

"This rock has a black colour; is always intermixed with mica; and passes on the one hand into sandstone slate, and, on the other, into clay, where the schistose character is more difficultly distinguishable. It acquires by the action of the weather, an iron-brown covering; so that the rocks at a distance have much the appearance of the weathered serpentine rock in the Shetland Islands. It is quarried to a considerable extent in different parts of the island, particularly near to Stromness, and the slabs are used for roofing houses, but they are vastly inferior in every respect to the ardesia which is raised at Ballyhullish and Easdale."

This is the description of perhaps an unusually bituminous variety of what is now called Caithness-flag, and it unquestionably passes into "sandstone-flag." Jameson makes it also pass into 'indurated clay.'

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The lower series of beds are of a deep-red colour, from their containing much of a reddle-like mud disposed between the quartz grains, but this mud is of so clay-like a substance that it cannot be said to act the part of a cement to these grains. The upper beds are of a distinct yellow colour; the interstitial material is here not so large in quantity, but it partakes more of the nature of a cement.

The lower red bed is first seen in the north, on the west side of the bay of Pool in Sanday. It here forms low cliffs to the east, and strikes southward through the island in the direction of Spurness. It reappears to pass through Shapenshay from north to south, is again seen in low cliffs on the west shore of Birstane Bay in the mainland, re-appears (here associated with the yellow bed) at Scalpa, and finally forms the north-west corner of South Ronaldsha.

The cliffs of the Noup Head of Westray, 240 feet in height, appear to be of the same yellow rock. By Sir Rhoderick Murchison they are laid down as on the same horison as the strata of the Hoy hill-tops. There should in such a case be a great fault to throw them down over the thick beds of the flags in Rousay. No such fault is to be seen upon the shore; and, moreover, the igneous rock which in Hoy is seen to underlie the upper sandstones, is nowhere that I know of here present.

As the dip of the Noup Head rock is to the east, it may be one of the beds to be afterward noticed as occurring in the island of Fara; and if this be the case, the strata included between the beacon on North Ronaldsha and the Red Head in Eda represent the total thickness of the Old Red formation in Orkney; and, as it can be seen, by a section along Sanday, to be thrown into repeated folds between these points, that thickness cannot be great.

These red beds repose perfectly conformably upon the ordinary blue flags of the islands.

In Sanday the yellow beds are not of great thickness, they are conformable with the red, and at a spot called Heclabir are overlaid, also perfectly conformably, by thin beds of a conglomerate.

Observations made during two visits to this spot, and an examination of specimens brought therefrom, leave a strong impression in my mind that this is a *volcanic* conglomerate.

Its extent is small, being about 35 yards in length by 41 in width, and its total thickness is under 14 feet.

A fairly good section is exposed in a chasm of the rocks; as a road leads directly to the spot, this would seem to have been an old quarry. The stone may have been used as a burstone in mills.

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The general dip of the rocks here is to N.W. by N., at the angle of 40°. The chasm has been cut at the angle of 30°; an opposite affect to what would have been produced by sea-breaching.

At the bottom of the section visible at the locality, there are yellow sandstone beds with ripple-markings. Above these, six feet of sandy flags, very fissile at the top. Over this, one foot of sandy clay containing small pebbles lying in every direction: over this, one to two feet of green volcanic (?) mud, slightly wackenitic, also with small pebbles lying in every direction. There is next a few inches of sandy grit, capped by by about five or six feet of a tough conglomerate.

This conglomerate is made up of nodules considerably rounded, and of sizes varying from the size of millet grains up to that of the fist.

The rock-rents cut the pebbles, sometimes shifting them to the extent of an inch; but I saw no pebbles in which the fractures were not connected with the rock-rents.

The conglomerate-cap shows false bedding in the layers of its pebbles, with occasional basin-like bands of grit.

The pebbles consist of *granites*, of more than one variety; *gneisses* often chloritic; porphyrys; and seemingly of *quartzite*;—rocks which are altogether different from the primitive rocks near Stromness, and therefore rocks *not occurring in the islands*.

Both the pebbles and the cementing paste have a highly vitrified aspect.

I have been informed that a conglomerate identical with this is to be seen on the coast-line at the south end of the Calf of Eday, which bears N.W. by N.; and, at low water mark, on the shore of Eday, directly opposite to Heclabir, *i.e.* W.N.W.

Be this as it may, the conglomerate underlies a much thicker series of beds of the Red Sandstone; these come in on the Island of Eday, forming its Red Head, and giving this portion of the series a thickness of about 200 feet—the dip remaining much the same. The Grey Head of the Calf of Eday may be a local expansion of the yellow beds, but a fault may run between Sanday and Eday.

Yellow beds with an opposite dip are to be seen in the island of Fara.

Quarries of both of these coloured sandstones have long been wrought in the Island of Eday; from these probably, the high-tinted stones of "the beautiful gate" of the Cathedral of St. Magnus, if not indeed of the whole of that structure, have been taken.

It has been stated that a narrow strip of older rocks occurs in the west of the islands.

This is, to the south, first seen in the island of Gremsa, of which these rocks form perhaps a fourth part; it re-appears on the opposite shore of

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the Mainland, extending in width from the Point of Ness on the west, to the mill-water of Cairston on the east,—probably about a mile. Thence it runs north for about four miles towards Inganess point, where it has thinned away to a breadth of a few yards, and where it is sharply cut off by a trap-dyke.

The exact horizon of the beds which repose upon the flanks of this wedge (they have been removed by denudation from off its surface) could only be ascertained by a careful section across the whole island.

This primitive belt consists for the most part of a fine-grained granite, with a dark mica: towards the eastern side there is a tendency to a passage into syenite, while on the western there are gneissic beds, though of no great thickness, superimposed upon the granite.

Upon the west side of this mass there lies a conglomerate, gradually passing into a gritty sandstone. This conglomerate is formed of highly brecciated particles of the gneissose and granitic rocks; it is over-laid by flaggy beds which dip uniformly and persistently to the west, as far as the land continues.

The beds in contact with the primary belt upon the east also dip away from it for some space; but, at some points of the easterly contact, ferruginous argillaceous-flags are seen with a N.W. dip of about 8°.

The details of the section to the west of the belt of primitive rocks as seen on the sea shore in the vicinity of Stromness is as follows:—

Immediately at the Point of Ness—best seen at low water—there is granite possessing much of the features of granulite. This is overlaid by lepidomelane-gneiss which dips S.W. at the angle of 15°.

The beds of gneiss are very thin and are succeeded and overlaid by conglomerate, composed of fragmentary nodules of the underlying gneiss. This conglomerate has a thickness of only about 20 feet; its dip is as great as that of the gneiss, but it is to W.S.W.

The conglomerate is succeeded by argillaceous-flags, which are somewhat gritty when in contact with the conglomerate. The argillaceous beds are overlaid by ordinary fissile flags, up to a small bay near a life-boat house. There is now, however, a fault with a considerable upthrow, granite tending to eurite re-appearing. The granite is traversed by interlacing veins, and continues for a distance of 40 yards. It is succeeded by a conglomerate, which contains nodules of gneiss and granite—these nodules lie in all positions. This rock continues for 100 yards. It is overlaid by thin beds of a gritty conglomerate, to which there succeed flags containing plants, some of which were considered by Dr. Fleming to be fucoides.

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These flags are succeeded by others showing many sun-cracks; while some beds are profusely sprinkled with rain-drop pittings. The dip of the beds which supervene upon the fault gradually turns to the west, while the angle of the dip, never so high as that of the beds eastward of the fault, is gradually diminished to 7°. These beds continue for half-a-mile, when they are succeeded by others of a finer grain, in which are entombed multitudes of fishes. These fishes are converted into a substance of a pitchy blackness, which but seldom retains more than the general form of the organism. In such as are sheathed in a bony carapace, the blue tint imparted by phosphate of iron is frequently observable.

In these beds *marcasite* nodules are rarely found, *calcitic* veins fill cracks which run south: Thin veins of *stromnite* occur both in the flags and in the conglomerate. Two trap-dykes with associated *lydian-stone* cut the strata from west to east.

The *lydian-stone* occasionally has a structure resembling fossil-wood.

The conglomerate rents are small: they cut the nodules rarely, but do not shift them.

Piecing together this evidence, and reading therefrom the record of the rocks, it is evident that, though in no place do we see the basement layers, the Orkney beds were deposited upon a very uneven bottom—the bottom, so far as Orkney discloses, of a shoreless sea—a bottom from which in one spot there protruded first a rocky gneissic islet, converted by a sinking land into a skerry-like ridge, against which the surf of a westerly-sea beat, so as to form a fragmentary shingle. That through the continued sinking of the land there had been deposited upon the conglomerate so formed, first, the muddy silts which, exposed to sun and rain, became the pabulum of plant life; and secondly, the still muddier deposits into which the remains of animal life sank and were entombed. Lastly, the dipping away of the strata from both sides of the supporting ridge,—and that at an angle which, in the immediate contact is higher than that which is normal to the series,—speaks unmistakably of local elevation and protrusion of that ridge, probably anteriorly to, but at least independently of the general elevation of the land.

As a locality of special geognostic interest, the coast line from the Bay of Skail half way to the Black Craig, on the west side of the Mainland, may be instanced.

The various points of interest along this shore are not only numerous in themselves and diverse in their nature, but they are also seen with very unusual facility; they moreover present themselves with very unusual clearness.

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The locality is, in the first place, an open book of illustration of the *warfare of nature*—of sea and air sapping the foundations, and scalping the cornices of the bulwarks which confine the former in its bed.

These illustrations are very different in their mode of operation to those noticed when speaking of the coasts of Shetland; *there* the assault was direct, and unmistakeable; here, on the other hand, it is insidious, and is carried into effect frequently by what may be called a flank movement.

This diversity in operation is due to the difference in the nature and bedding of the rocks. Here the strata, consisting of thin-bedded and unusually-fissile schists, repose in sheets, which are nearly parallel to the waves at their base; the dip being only 2°, and to the N. ¼ E,—that is at right-angles to the line of coast. The seams of the rock are thus as open to the insinuation of the wave-wedges, as are the leaves of a book to the thrust of a paper-cutter.

Again, the beds are cut at right-angles to their dip, by a series of trap-dykes which have filled up pre-existent rents. These rents were merely the most widely-gaping of a system which cuts the rock with very unusual frequency. The slabs of rock thus lie almost unattached to one another in two directions, like a number of closely adjacent packs of cards,—ready to be displaced whenever the disrupting force is sufficient to separate them by merely overcoming their gravity.

But gravity may even aid the displacement, should the circumstances admit of its coming directly into play. At the southern corner of the Bay of Skail, the circumstances are such. Here two closely-adjacent dykes have cut the interstitial beds loose from any but their own adhesion. The surface-waters, playing upon the jointed and rhomboidal blocks, first widened the open joints by their solvent soak, and then lightly lifted them out of their seats, towed them from the land, and thus gradually tunelled a low and deep-water cave between the dykes. As these cut a promontory from side to side, the straight-sided tunnel so formed passes through the land, forming what is called the Hole of Rowe.

Heavier surfs and loftier surges forthwith lashed their spray against the roof of this low passage, opening out the rents between block and block, and between these blocks and the retaining igneous walls. Gravitation now aided the rending, and slice after slice of the sandstone was dropped into the waters, just as card after card falls from a horizontally held pack, when the grasping fingers are gradually relaxed.

The falling in of the roof of this tunnel is but a question of time; ultimately a *stack* of Rowe will appear,—the sides of the intervening chasm being sheathed with trap,—leading perchance to the false conclusion that a strike of unusual width had yielded to the assaults of the sea.

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Doubtless it is on account of this unceasing widening of the horizontal crevices in flatly-bedded rocks, through the sap of the waters, that we so generally see a dip of these rocks away from the land and towards the sea,* whatever be the dip further inland. Gravitation closes up the open joint *pari-passu* with the widening,—folds the land prone to the waters,—till the *nodding* tears open a longitudinal rent, and the dissevered mass gradually "topples to its fall."

It has been said that the agents of destruction often operate by flank-attack; the cutting out of the Hole of Rowe has been indeed much of that nature, but a more decided illustration is in the near neighbourhood to be seen.

The cliff, marked in the Admiralty Chart as 180 feet in height, is capped by a shallow covering of turf, with underlying ochery-clay. The land rapidly falls landward to a hollow, scarce a hundred yards distant.

This slope is cut into wide and deep channels,—the beds of streams which must sometimes rush in brimful fury. But these channels commence but a few feet from the brink of the precipice; and the water-shed is so narrow that in the most rainy weather merely a trickling stream follows their landward course. Not so, however, when the Atlantic surges top the verge, and the overflow of the loftier billows, sweeping along in salt-water rivulets, fills them to the brim, and by rutting out an ever-widening channel, acts as a pioneer to the ordinary operation of the waves in cutting sea-stacks from the land.

Still another illustration of the battle of the elements is here to be witnessed.

Higher up upon the grass-clad banks, a gun-shot and more from the brink of the precipice, lying loose and lightly-poised upon the sward, there lie numerous flakes of stone. Around them, and between them and the sea, the grassy banks are all unbroken; the surges therefore did not lay them there,—but the wind, forcing itself wedge-like into the crevasses of the many-jointed and thin-bedded strata, had torn them from their beds and scattered them over the land like winter leaves.†

* I am indebted to Dr. Jobss, of Golspie, for *pressing upon my attention* this too-much disregarded fact,—it is far from universal, but is very general. The explanation is patent.

† The Revd. Dr. Clouston thus describes the aspect of an ordinary gale at this spot. "During a storm from the west the scene is awfully grand. The large accumulations of water that then roll after each other, foaming with terrible violence to the shore, impress the mind with irresistible power, and might well give a stranger a feeling of insecurity; and, when they dash themselves against the precipice, it seems half sunk, for a time, like a wrecked vessel amid the waves; sheets of spray are thrown far up into the air, and carried over all the country, making springs a mile from the coast brackish for some days, and encrusting everything with salt, even fifteen or twenty miles off.

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At some spots of the coast, the numerous joints and cross-rents of the rocks have produced an appearance much resembling a shattered tesselated pavement. Jameson, Fleming, and many older writers have noticed it.

In Wallace's "*Account of the Orkney Islands*" published in the year 1700, he thus describes the locality.

"At the West-end of the *Mainland* near *Skeal*, on the top of high rocks, more than a quarter of a mile in length, there is something like a street all set in red clay, with a sort of reddish stones of several figures and magnitudes, having the images and representations of several things, as it were, engraven on them; and, which is very strange, a great many of these stones when they are raised up have that same image engraven under, which they have above. This causeway is all along the tops of rocks, and though they be otherwise of a very considerable heighth above the sea, yet the West Ocean in a storm leading that way, does dash with such violence against the rocks that the sea breaches do wash the ground on the tops of the rocks. If these stones had not the same figure on that side next the ground as they have above, I should think the sea washing over them might occasion these different figures, by washing away the softish parts of the stone and leaving the harder, and so accordingly give them these accidental shapes and figures. Tho' there are a great many of them still remaining, yet the gentlemen living near that place have taken the prettiest figures to set their chimnies with, as they use to do in *Holland* with painted bricks and tiles."

Dr. Fleming, in the 8th vol. of the Edin. Phil. Jour., thus describes it.

"The strata have an inconsiderable dip, and consist of thin slaty sandstone, abounding with argillaceous and ferruginous matter, with minute scales of mica. The uppermost layer or even layers when exposed to the action of the atmosphere, aided occasionally by the spray of the sea, becomes divided into numerous tabular pieces, by means of vertical rents, and exhibits the appearance of mosaic work. These tables are irregular, but differ in the number and relation of their angles, although they sometimes exhibit regular geometrical forms. Upon the layer being thus

am told by those living a few hundred yards from the spot, that the floors of their cottages are shaken by the violence with which the waves strike the crags, and I have seen innumerable sea insects alive on their summits, and even a limpet adhering to them after such a storm also numerous fragments of slaty stone, some of them a foot long which had been whirled into the air, and had penetrated six inches into the soil in falling.

On the top of one of these crags I once picked up a lump of India-rubber covered with barnacles.

Not far from Rowe, is an immense rock. which is well known to have been carried a nsiderable distance by the sea; it is 16 feet long, 6 broad, and 3 thick, and weighs, rding to my calculation, 24 tons.

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divided, decomposition speedily takes place. It proceeds from the sides towards the middle, and as the decomposed matter is washed off, the table exhibits a depressed border, marking the extent of the decay, having the middle raised, and consisting of unaltered matter. In some cases there is a well-marked groove, separating the two portions. In both varieties there are prominent irregular pieces of the rock, which seem little liable to decomposition."

To me there seemed to be a greater amount of regularity in the cleavages and angles than Fleming seemed to have observed. The rock almost always splits up into lozenge-shaped fragments. At one locality these were generally pretty uniform in size,—being 7 inches by 6; at another the general size was 6 inches by 5.

The averages of many measured angles of the lozenge were 109° 30′ and 70°30′—the greater angle varied from 106° to 114° the smaller from 67° to 72°30′. Dr. Fleming remarked that the number of angles differs. This would, however, appear to be due to the simple truncation of the acute angle of the lozenge.

The depressed border, generally of a bright yellow, is about an inch in width and is usually margined on its inner side by a trench and raised ridge, each differing in colour; there is thus produced a structure of singularly artificial appearance.

The splitting up of this rock and the manner of its weathering is assigned by Dr. Fleming to the action of the air and the spray of the sea; the splitting up of the rock at least might with greater probability be assigned to a certain amount of definite structure in the stone; and when it is observed that both the thick and the thin flags of the country show a general tendency to a rhomboidal arrangement between their strike and dip-joints, there can be little doubt that this is the true cause.

Indeed the very marked regularity and persistence of the jointing of these Orkney flags determines to a very great extent the marginal contours of the rock as a whole, and its endurance or decay under the influence of the agents which are free to affect it where exposed in the rock fringes which mainly gird the islands.

A long familiarity with the sea-cliffs of this formation, and a close consideration of those of other formations, has convinced me, *first*, that whether the agencies of decay operate singly or cumulatively, the rapidity of the decay, destruction, or local transfer, is to be assigned *far more to internal weaknesses*, either physical or chemical, than to external agencies. *Secondly*, that in our attempts to interpret the operations of nature, *there is far too great a tendency to ascribe change to the sudden and violent operation of the forces of convulsive effort,—to the almost total disregard of*

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the gentler and continuous operations which, through their being protracted in time, come to be insidious in their workings.

That the precipices which girdle our shores are in one sense *sea-cliffs* is most true, but that they were all or to any great extent *sea-cut* cliffs is more than doubtful.

The sea maintains the perpendicularity of the cliff, it is true, by sweeping away the debris from the foot; but very seldom has the sea formed the cliff, by a continuous battering of the looser rock-layers at the summit; or by the breaching of an undercut recess at the foot, so that gravitation by the rent of a sudden fracture hurled the overhanging mass into the ocean. The rent was an open joint,—a component feature of the rock-structure,—independent altogether of gravitation's working, and while yet the sea was far off from that portion of the land.

On studying all the varieties of cliff which are to be seen in these islands, the observer will note that they group themselves into three forms,—that these forms are invariably associated with the dip of the strata,—and are only well defined if the dip is decided on the one hand, or if the stratum is horizontal on the other.

In those cases in which the dip is seaward, an outlying tidal-skerry with its wedge-like slope, forms a breakwater for the land; the surges are for the most part spent in force in the intervening channel; and but a low fringe of broken cliff protrudes from the land,—which, in such circumstances, thrusts itself beyond the usual line of the shore.

When again the dip is towards the land, a lofty precipice with step-like front, formed of the strike-joints usually at right-angles to the bedding, is the form assumed.

But the form which far most commonly arrests the eye, is a straight-lined and truly mural sheet of rock, which stands erect out of the waters, either directly in the general line of the shore, or projecting boldly seaward nearly at right-angles thereto.

Brief inspection shows that these sheeted, and wonderfully smoothly-cleft faces of rock are merely the joints of the stratum; longer inspection shows another set of open joints to run far inland at right-angles to the coast-line, and rents continuous with these or parallel thereto to succeed one another, with scarce any diminution in their frequency, till the sward conceals them.

These "backs and cutters" then—the shrinkage cracks of the rock—determine the nature of the frontlet of cliff. That the face of the cliff has been formed by a sudden falling away of outside material is evident,—that the material which fell was borne off by the waters is equally so,—but that the waves *by their battering* produced the fall, is far from evident.

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The jointing is an element of weakness; in certain circumstances it may become an actual agent in the destruction.

Should these be any seaward dip of the stratum so that the strike-joints overhang, should these joints reach to the lower stratum, and should their frequency be such that the centre of gravity of any of the slices thus about to be cut from the land overhangs its base, then its fall is prevented merely by the molecular adhesion of its basement layers. This, feeble at all times, may be overcome by the vibration into which a single billow may throw the whole mass; or the wind may overwhelm it in a gale; or air-rotting may crumble its support.

Even indeed where the jointing is not so frequent or so close as to produce such toppling masses, they may be brought into a toppling condition by a process of wedging from above.

Near Hoy Head at a height of over 1000 feet, parallel to but far back from the cliff edge, long gaping chasms are to be seen, more or less filled with earth, clay, and jambed blocks of stones.

Into what was first of all a mere line of cross-cleavage, the entering air, by peroxidising the iron compounds, threw scale after scale from the mouldering rock, widening the crack above, and supplying material which hereafter would perform the function of a wedge. The process is one in which the operation progressed in ever increasing ratio of speed:—the downward progress of the rent opened a way for the operation of a water-wedge. Here the fashioning of the line of cliff, left to the operation of such agents alone, depends upon the relative amounts of the adhesion of the rock laterally and vertically. If greatest laterally, then will the wedge displace but a small depth of the stratum, dislodging it along the lines of bedding. If the bedding be not distinct and free, then must the wedge find a slow passage till the waters entering from beneath dislodge the material which plugged the rent.

In such a situation the waves could take no immediate, or at least primary part in the remodelling of the cliff; but it is not meant to be insisted on that the sea plays no part in the circumstances ordinarily obtaining.

There the ocean is ever lying in wait, surging and seething round the foundation-strata, sapping into every chink, and ready to spring at every weakened joint. Rushing with concentrated force up two closely-adjacent cross-rents it may lift out the intermediate blocks to make a widened *geo*, simulating a washed-out trap-dyke; or it may and often does remove the material of true dykes. No weakness can be hid from it; and, as the gales run round the different points of the compass, a crevice cut at right-angles to the first, allows the waters to meet those circulating in

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it, and a quadrangular sea-stack now stands apart from the land. The waves, moreover, ever remove the debris of each fall, and so allow no prop to impede the continuance of the destruction.

But while thus admitting the part they must thus play, too much stress cannot be laid upon the assertion that the special conformation of the cliff-scenery of the Old Red Sandstone is due, as Geikie puts it, "not so much to the breakers (though their force is enormous) as to the less conspicuous action of atmospheric agents, which cut slice after slice from the edge of the land."

The situations in which among these islands the waters would at least appear to be the chief factors in breaching the land, are three.

First, water-floored caves; the second in the case of lofty projecting headlands, such at least as are not protected by a boulder-beach of stones; and thirdly, deep re-entering bights into which the waves converge as into a funnel, and up and over the converging cliffs of which they rush with heaped-up volume, and almost incredible might.

The first of these cases or localities are those in which a superficial observer would decline to accept the conclusion—that it was not the operations of the sea which had alone to betaken into account. I advert to those deeply-burrowing caverns—frequently with rounded, widened, and roofless terminations,—called *gloups* or *syngens*, in the language of the north.

As there is no part of Scotland in which there are so many or so fine illustrations of these, I take from the "Statistical Account" of the islands, and elsewhere, the following descriptions of such.

In the description of Westray, we read—"Here (Noup Head), besides many curious excavations in the apparently solid rock, are to be seen subterraneous caverns, formed by the influx and reflux of the sea. In some of these, the water at high tide, and in tempestuous weather is forced up through narrow crevices of the rock to the distance of nearly a quarter of a mile landward, and bursting out at the surface from orifices of its own formation, springs up in the air to a surprising height.

"Among the natural curiosities of the kind here to be met with, that called The Fort, evidently formed by the action of the sea, may not be deemed unworthy of notice. This remarkable place is situated on the northern boundary of that part of the island called Akerness. Here, standing upon a lofty precipice, you see, underneath, an immense cauldron in perpetual agitation, from which a hideous and gorging noise ever and anon ascends, stunning the ear. You can walk nearly half way round this mighty cauldron, on high pillars of solid rock, arched over with the same solid material. One or two broken or separated columns standing

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out furthest in the circle, from which the arches seem to have been swept away by the agitated element, heightens very much the grandeur of the scene, and gives to it an appearance truly picturesque."

"On the north extremity, Papay Westray terminates in a headland, bold and lofty, called the Mull of Papay. At this headland, is a cave, deemed one of the greatest natural curiosities of the kind to be met with perhaps in all the country. Its interior presents the appearance of an immense amphitheatre. The roof, upwards of 70 feet in height, is somewhat like a regular built arch,—the beds of rock on every side rising the one above the other, in the form of steps in a stair. The entrance is about 50 feet in width, the breadth of the middle part about 60, and the most interior 48. The floor has a little inclination outwards, but its surface is smooth and even to the foot. It is called the How of Habrahelia."

"In the vicinity of Halcro Head, in South Ronaldshay, there is a remarkable cavity known as the 'The Gloop.' In a heath-covered mound, some two hundred yards or so distant from the shore, there is an opening like the crater of a miniature volcano, and far away down in the abyss you hear the sullen plunging, gurgling, and groaning of the imprisoned sea. The waves have excavated a long subterranean passage or gallery, which echoes with their thunder-boom in the day of storm."

"On the west side of Scalpa Bay, there is a cave called the Salt Pans, which runs parallel to the shore to the distance of twenty paces. The front has the appearance of freestone pillars, placed at irregular distances of about five feet. Above and below, and also behind these pillars, there are *rocks of harder stone*."

"At the Vat of Kirbuster in Stronsay, the sea has broken a magnificent archway through the front barrier of rocks, and, having once forced a passage the waves dashing and lashing through the archway for centuries, have formed an enormous excavation among the rocks behind, which being open to the sky, presents on a huge scale some resemblance to a vat. The archway may be likened to some work of massive Titanic masonry, and there is a wild sublimity in the hollow echoing boom of the waves as they bound from side to side of the arch, and break in foam within the mighty caldron of stone."

Similar to these are the "Syngens," near Scabrake Head in Rousay, and near Snelsetter, in Walls: in one of the latter, the communication with the ocean is always below low-water mark, notwithstanding which the mast of a vessel was once found floating in the land-encircled basin.

Other similar ocean-floored caverns have been noticed at Scraada, in Shetland, and in Fair Isle; and those of the Gellie Pot, near Arbroath, and the Bullars (boilers) of Buchan are well known.

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In all of these, though the sea is directly the instrument of destruction, —as even the description of the Fort in the "statistical account" would indicate,—yet it is equally evident thatsome local peculiarity, conformation, or weakness of the rock, as directly accounts for the *exceptionality* of that destruction.

Where the sea penetrates it the extraordinary distance of "nearly a quarter of a mile" beyond the ordinary coast line, as vouched for by the pastor of Westray, there must have been some extraordinary softness or looseness, or facile-solubility in the mass removed. In this case, a crumbling dyke of trap, in that, columnarly-crevassed basalt, here, a soluble calcareous-seam, and there,—as at the Gally Pot,—a vein (baryte) with loose attachment to its walls.

So that in these cases, even more than in the circumstances which ordinarily obtain, we are brought back to the same conclusion—*inherent weakness* in the ordinary case,—*exceptional weakness* in the extreme cases.

The Bery Head in Walls, and the cliffs of Foula are instances of the second of the situations in which water would appear to have been the active trencher upon the confines of the land: here the sea by undercutting, may have induced a true rent from top to bottom.

Rackwick Little, and other points between Melfea Hill and the Bery on the west side of Hoy, are instances of the third. In the riven and crumbled rocks, the torn up turf, and the subsoil gashed far back from the cliff edge, the spectator will see evidence of the operation of some agent of terrific might; but when, he contemplates the height of the cliffs, he will be slow to believe that the waters of the ocean sleeping at their foot can have been so elevated as to have been that agent. Only the seeing them in the work of destruction, or the observing live limpets adhering to the summit of the rock after a storm, would help him to believe in so tremendous a displacement.

Yet in the ordinary case their effect is but small. Some estimate of the amount of its action may be arrived at from what the writer was so fortunate as to witness during a storm of unexampled violence which occurred in the winter of 1851.

The locality at which the effects of this storm was witnessed, was the Scabrake Head in Rousa,—one to which strangers visiting the island are frequently conducted to witness the spectacle of the ocean in wrath.

This headland consists of a mural wall of rock of about 120 feet in height, which faces the north-west. At the southern extremity of this extended wall there is a projecting bastion, termed from its form The Knee; from this, as it is thrust at right-angles to the main cliff some distance ocean- the lash of the waves against the great wall, and the turmoil of the beneath can be viewed to advantage.

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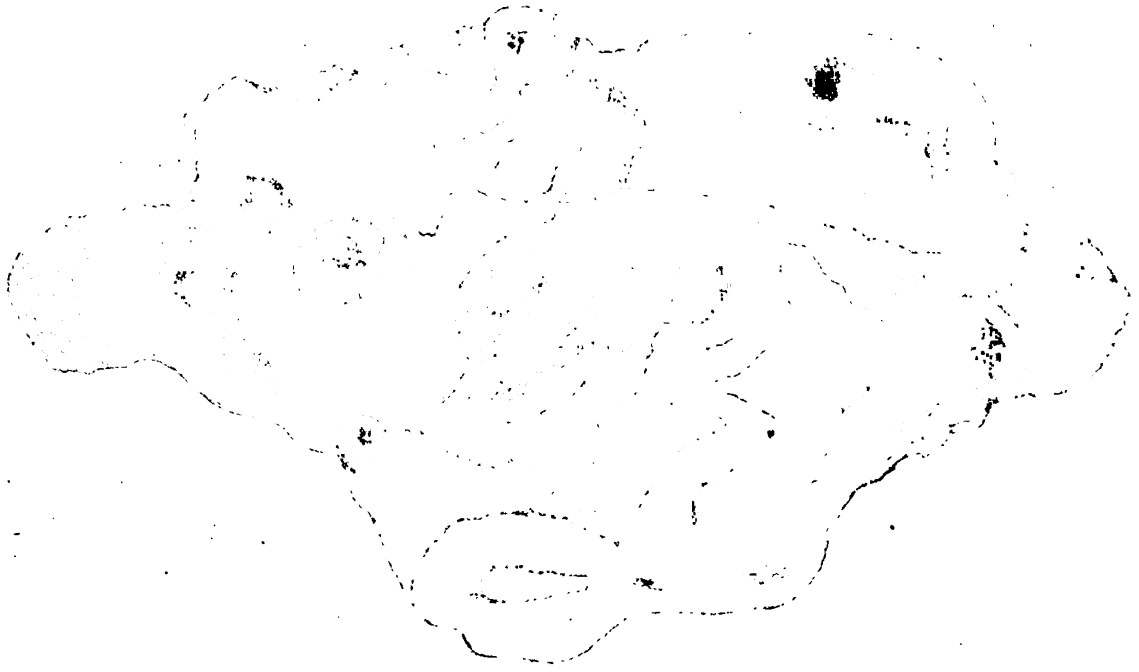

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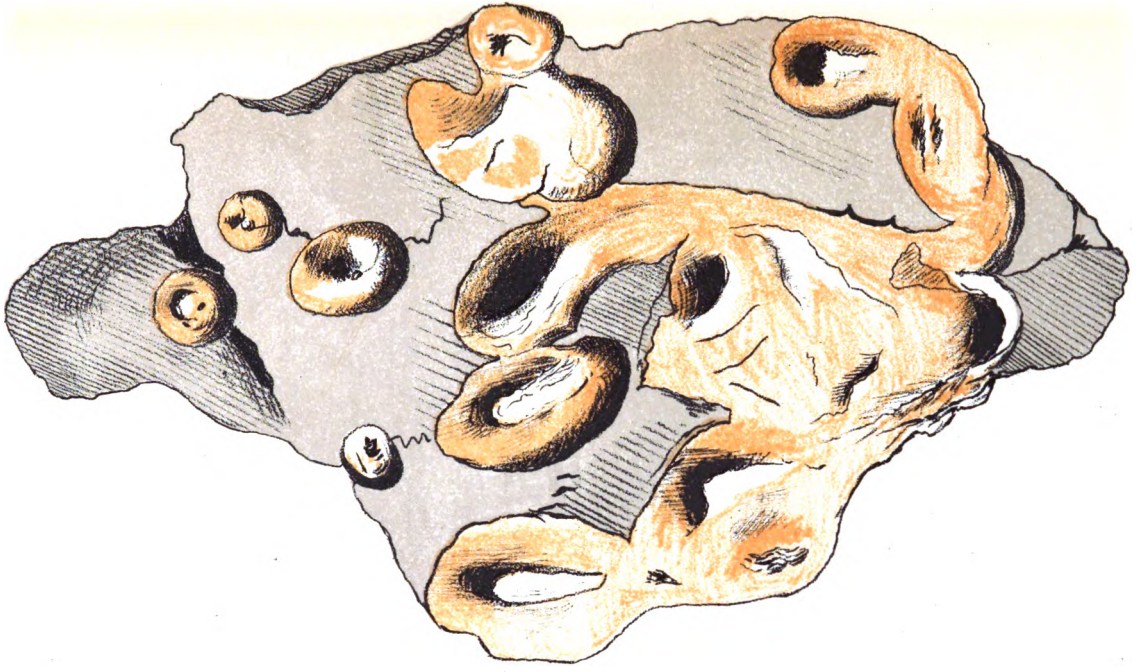
"HORSE-TOOTH STONE."



FROM ABOVE.

LAKE & LAKE, LITH. TROY.

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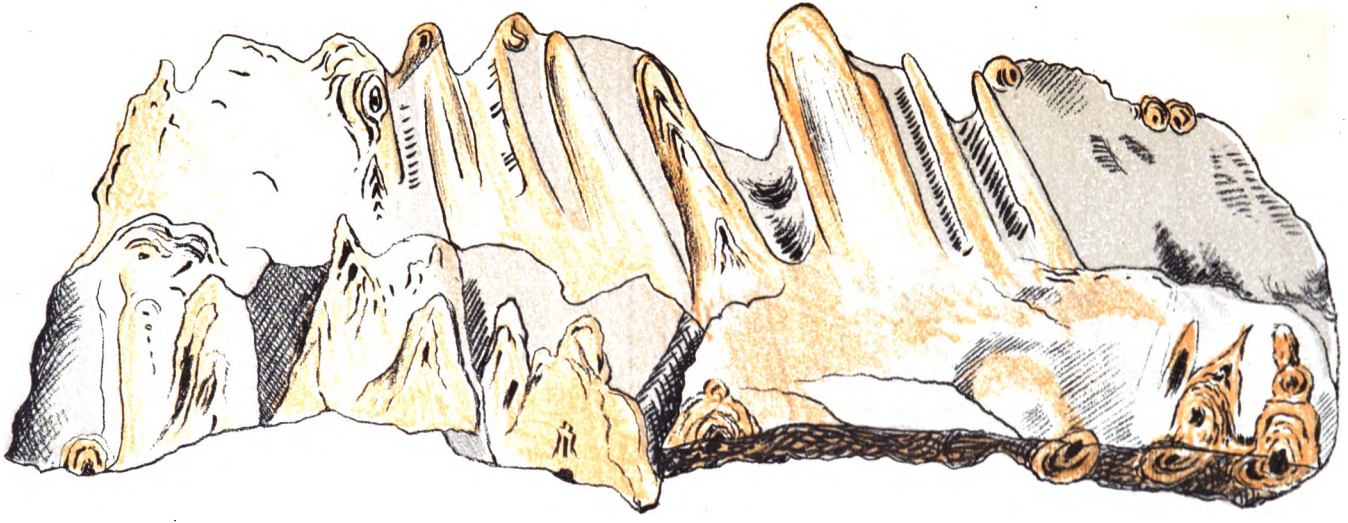

"HORSE-TOOTH STONE."

TRANSVERSE FRACTURE.

F. H. Del.

LANE & LANE LITH. TRURO

Plate XV.

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The cove between these opposing fronts of rock is a very place of storms: except in the calmest weather, the agitation is here incessant, and this is occasioned by two circumstances.

The first, that across the ocean, and right in front of this cove, the *röst* of one of the swiftest tidal races in the islands* runs with its curling waves and resistless rush of waters, in the very face of the incoming billows of the Atlantic. The second, that the moving mass of oceanic water, somewhat broken in its continuity and irritated into increased volume by the convergence with itself of the huge masses of the rollers of the *röst*, finds itself, as it enters the funnel sides of the cove, suddenly shot up from a depth of fifteen fathoms, to one of four. The result is that, there no longer being depth commensurate to the amplitude of its oscillation, it *peaks into a breaker*, and flings itself at the cliff with a volume and a violence which is altogether exceptional.

In an ordinary gale of wind then, there are four circumstances which here combine to enable the force of an ocean-billow to operate with extreme and abnormal violence.

There is *first*, the directness of the exposure to a mass of water of say 20 feet in height,† the undulation of which is rushing over the ocean surface at the rate of from twenty to thirty miles per hour.

Second, that undulation has to run diagonally across the rush of the waters of the tideway, which are moving in an opposite direction at say 7 miles per hour,—and it catches right in the teeth, and coalesces with the rollers of that tideway, which are as lofty as itself, though far from as ample.

Third, its waters come to be heaped up latterally, by the sides of a widely extending and converging V shaped shore.

Fourth, they are thrown vertically upward by the rise in the bottom, but there is still depth enough, and perhaps just depth enough for them to submit the cliff to the full concentration of the blow.

On the occasion refered to by the writer, a succession of westerly gales had continued for about eight days; on the morning of the last, the tide rose to a greater height than it had done for twenty-eight years, and the gale

* This Röst has thus been described by Gorrie in his "Summers and Winters in the Orkneys."

"Listen! and you hear a roar from the nor-west, as if the Atlantic were about to burst down upon us with the thunder and tramp of irresistible waves. It is the Roost of Enhallow, swirling, tossing, and boiling in the ebb-tide—a terrible sea-cateract from which unskilled navigators might well pray to be delivered; happily for us. our course did not lead us near the foaming lips and roaring throat of this Maelstrom of Enhallow."

† Dr. Scoresby measured, in the Hibernia. Atlantic waves 33 feet in height. In the Royal Charter he measured waves at the Cape of Good Hope 45 feet in height. The highest wave which the writer measured during several months in the Atlantic was 21 feet.

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raged with a fury which exceeded that of any within the memory of the islanders.

It is altogether beyond the power of the writer, if not beyond the power of language, to convey any idea of the spectacle which was seen from the summit of The Knee upon that day,—beyond saying that the violence of the blows which the cliff received, the height of the billows, the distance to which the broken waters were wind-borne landward, the size of the masses of flying foam, and the lashing and seething turmoil, altogether surpassed anything he had seen either there or elsewhere.

Though, however, description fails, some of the *actings of the waters* may be in bare language stated.

There was no regularity of motion whatever in the embayed water—it was a tortured mass which was twisting and tossing in an unceasing turmoil. Into this seething mass the greater billows would roll, as usual in sets of three; the upper waters of the first would spring back like a shower of snowy bullets discharged from the stricken rock; the back-tow of its recoiling mass would meet the upheaval of the second, and the united volume would spring aloft in a lighthouse-like form, level with or overtopping the main cliff. The third wave would throw itself headlong into the falling and subsiding vortex. So frequently did this happen, that it seemed to be worthy of consideration whether this habit of the ocean of rolling ever in three giant-waves, followed by a succession of minor wavelets, was not a provision for checking the power of the billows to rend the shores,—there being, in this mode of their action, a clear indication of self-destructive effort;—certainly so as regards this special locality.

But the rock did not always escape the full force of the blow of the greater wave, though during the time it was watched, it was so struck only some six or seven times. About one half that number of times, the wave was beaten back; the other half *it topped the cliff*.

With a seeming rush, as if it were pervaded with an actual intention, it would fling itself against the cliff and strike it in full force. On these occasions the shattered water shot up into the air erect, but in such ponderous masses that they were uninfluenced by the gale, falling vertically back to the spot from which they rose; these masses of water were thrown to a height apparently two-and-a-half times that of the cliff itself.

When it topped the cliff the spectacle was an inconceivably grand one. Like a solid but plastic mass, it curled over the verge,—a wondrously beautiful mixture of pellucid emerald, streaked with the purest white. The waters rushed with seemingly resistless force far up the land-slope—returned with a noise like the roll of many wheels, and fell back along

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the whole extended line of the cliff, muddied and discoloured, bearing great slices of the turf and stones,—a perfect Niagara of clay and water.

A somewhat similar development of power was seen at an adjacent locality. A projecting tongue of land,—narrow, but eighty or one hundred yards in length, 90 feet high at one end and 70 at its extremity,—landlocks a bight, which, from its proving a safe shelter for boats in ordinary storms, is called Providence Geo.

On every other occasion in which the writer had seen it in a gale, its sombre waters were smooth as those of a mill-pond. On this occasion a long extended billow, rolling towards its seaward side, suddenly erected itself, rushed at the cliff like the charging front of a regiment of soldiers,—seemed hardly to touch the basement of the cliff, but flung itself with curling cap right over the tongue, and fell into the Geo. In the Geo the waters were not greatly agitated,—a Cunard liner could have lain without much motion, but the pent up foam would have been mantling over her bulwarks.

Such a storm as this has never occurred since—it was the spasmodic effort of half a century. And what did it *accomplish?* It has been seen what it could *do*, but that was all froth and fury. *It did nothing in the way of altering the old landmarks!* When the waves struck the cliff the blow resounded like the discharge of far-off cannon, but the rock did not shake:—the crest of the cliff when examined afterwards showed much riven earth, and scalped soil, with a surface clean-swept of stones; but no mass was disjointed, there was no rock rending. In a few summers the turf would grow again—has grown again; *the ocean battery had accomplished nothing!*

Surely then we must conclude that the ocean is not the direct agent in the fashioning of the fringes of the land; that the chisels which cut the huge bastions of Foula and of Hoy, rank with the ceaseless and the abrading grasp of oxygen, the expanding dislodgement of the summer's heat, the soak of the raindrop, the influence of the balmy dew; that they are the agencies of the calm, and not of the whirlwind and the storm.

Among the beds in the neighbourhood of Yestnaby there are some thin layers of limestone, sometimes impregnated with bituminous matter and radiating *pyrite*, and one of these beds is possessed of a structure which I believe to be unique.

In the localities in which I saw it, it appeared to have been acted upon by the weather, so that the peculiarity of its r advantageously disclosed.

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It could be raised in slabs a couple of feet in dimensions, by three to four inches in thickness. Its upper surface exhibited a *pustular* and a *pitted* appearance. The pustules were the terminations of finger-like projections of calcareous matter; the depressions were due to the washing out of the dark blue laminated silicious and micacious rock which filled in the interstices between the projections. These were about one and a half inches in length.

When the laminated matter was uniformly chipped out from the calcareous, there remained a structure which *when inverted* bore a great resemblance to the roof of a limestone cavern from which there depended a multitude of regularly-spaced stalactites of nearly uniform dimensions.

When the slabs were broken into fragments, these bore a marked resemblance to a number of elephant's grinders, laid so that the fangs *presented upwards*. They are called the "horse-tooth stone" in the district.

When this calcareous band was fractured, it exhibited a structure similar in all respects to that of a stalactite—both the laminated structure of the dependent stalactite, and the circularly zoned and radiated structure of a transversely broken stalactite.

But the acuminated terminations of the processes which I have compared to stalactite *project upwards*. Had they been dependent, their formation would have been most difficult of explanation; as it is, it appears to the writer *inexplicable*.

The calcareous portion of this singular bed is of a dull ochery colour.

Sketches of this singular structure are given in Plates XIV & XV. The one shows the mastodon-like appearances of the cross fractures; the other the aspect of the surface of the bed. The hollows with the volcanic-like cones are the calcareous portions, doubtless dissolved out somewhat, and leaving a harder or less soluble core.

The interest connected with the trap-dykes of this locality lies in the very different nature of their lithological composition. Seven dykes are to be seen between the Bay of Skaill and the granite of Inganess.

Of the two which are closely adjacent at the Hole of Rowe, the more northerly shows merely crystals of *augite*, imbedded in the usual labradoric and augitic doleritic paste, the other contains in addition much *olivine*.

The three which follow have a direct magnetic east and west course. The first shows augite with imperfectly developed *zeolites*. The next is of a dense structure devoid of imbedded crystals, and has a highly-marked blue colour. The third is a ringing clinkstone.

The dyke which follows exhibits a marked departure from that rectilinear course, which characterises the great system of Scotch dykes. From a W. by N. it suddenly curves round to W.S.W. course, and as

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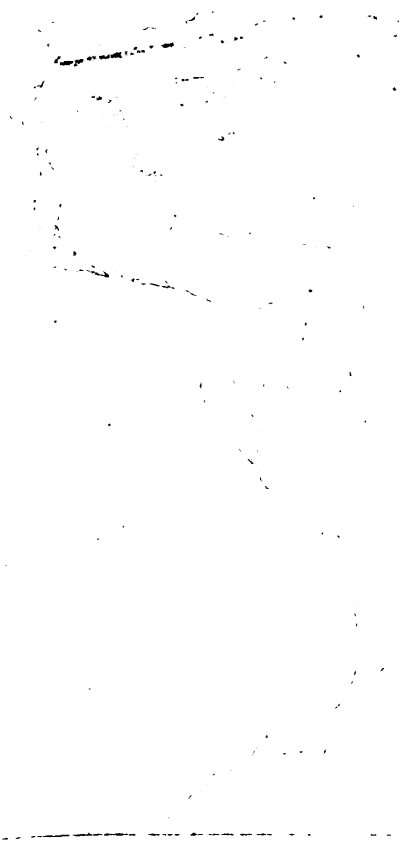

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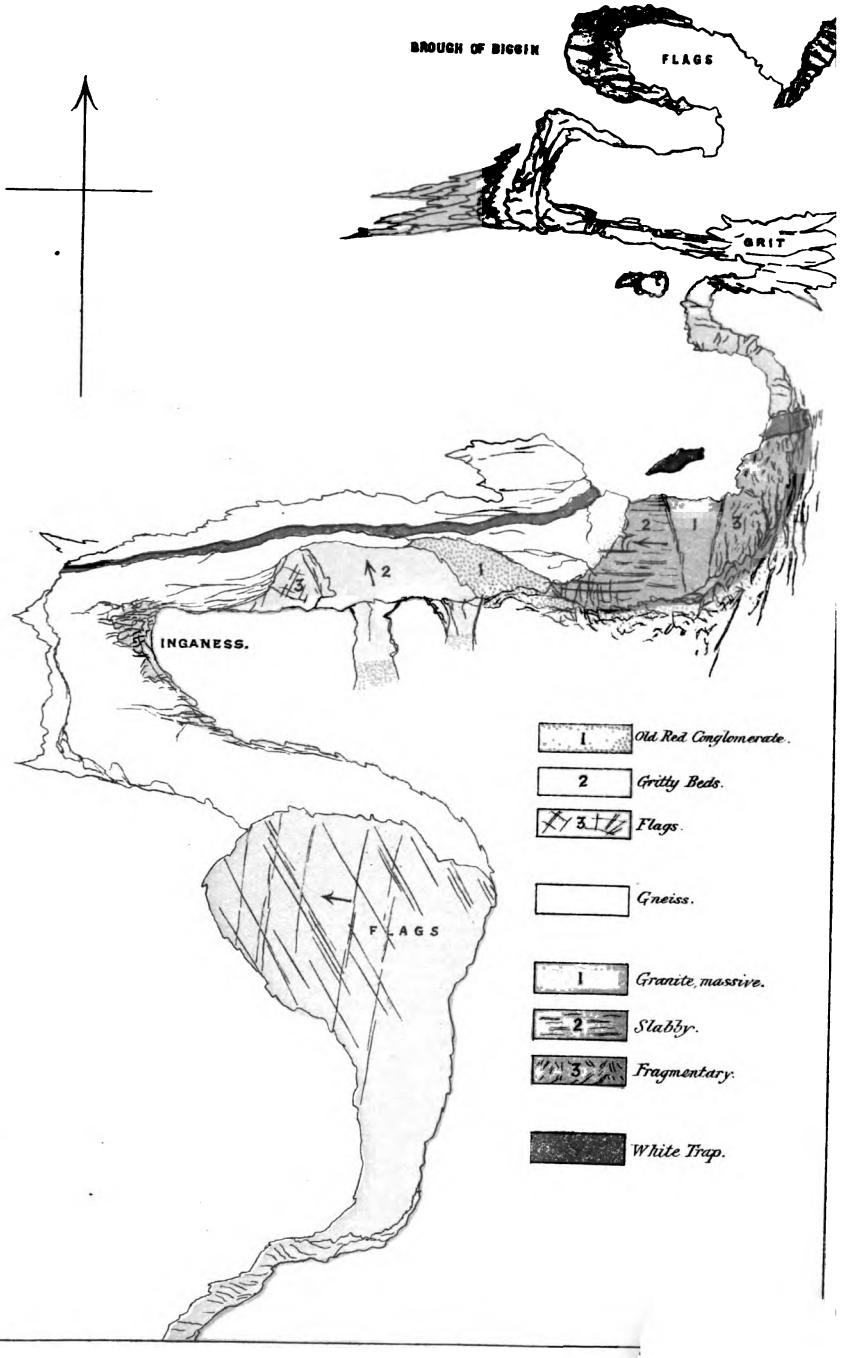

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suddenly regains its original direction, exhibiting thus a bold sigmoid flexure: its structure is amygdaloidal.

The seventh dyke, which cuts off the granite to the north, is almost white in colour from excess of its felspar, and minutely cryptocrystalline in structure.

Jameson mentions another dyke, (of this I however only found loose fragments), namely, one containing "crystals of hornblende more than an inch long by half an inch broad." These crystals are of a grey brown colour, and very lustrous,—the cleavage seems to be that of hornblende, but I failed in my endeavours to pick it sufficiently pure for analysis.

These dykes vary in width from two to about ten feet: the small distance to which the rock is indurated on the contact surfaces,—about a yard,—is much the same at both the narrow and the broad dykes.

The southern front of a cliff near to the Hole of Rowe exhibits an interesting mass of stalactite: the calcarious waters have found their escape solely at one spot of the surface of a single stratum of the rock, about forty feet over the face of the cliff. From the open bed of this, the concreted masses twine in wavy curves downward, like the curlings of a huge beard.

As the rock approaches the termination of the granitic masss at Inganess Point it becomes less argillaceous, till at one headland it is of the nature of a grit, and has been to a small extent quarried for millstones. As regards its hardness and toughness it is well fitted for such, but it is hardly of a sufficiently coarse grain.

The immediate locality where the granite terminates well deserves a close inspection, as it is a locality which will probably throw some light upon the metamorphism of gneiss into granite,—there being little doubt that such a change has here occurred.

From an angle in the shore-line the rocks have been exposed in cross and also in longitudinal section. A sketch has been appended. (See Plate VIII.)

The long wedge of granite previously described, seems to have nearly thinned off immediately to the south of a trap-dyke; but the sea has intruded here, so that at the spot where the central rib of granite presents itself, this cannot be absolutely determined.

On the north and south cliff-line a white trap dyke, which runs nearly at right angles thereto, separates the horizontally-bedded grit from a shattered mass of granitic-gneiss. The westerly continuation of this dyke shews itself as a small sea-stack, and it thereafter cuts the same gneiss which at Stromness is seen to overlie the granite.

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The central rib or core of granite which fronts the trap-stack is amorphous, and is rent by promiscuously disposed fissures; but to the west it becomes distinctly bedded and slabby, before it passes into laminated gneiss. The slabs dip to the west. In the central part of this east and west section, a conglomerate, formed from gneiss, passing upward into gritty flags, overlies the gneiss, with a dip to the north.

The gneiss which is cut by the dyke is much altered for four or five feet at contact, but it does not appear to have been faulted.

There is a small amount of disturbance both in the sandstone and the granitic-gneiss where it cuts the bank, so there probably is here a small fault which dies out to the west.

From the grit coming-in immediately to the north, the upthrow must be but small; but that a fault really exists may be deduced from this that there is no continuation of the granite north of the dyke along that which is its medial line: it is seen at Steinicknow in mass, and if it were not cut off it should appear (which it does not) still further to the north.

Turning the western point of Inganess, we find at a short distance south, the ordinary rhomboidal-jointed blue-flags reposing with a westerly dip upon the gneiss; and these blue-flags continue, with occasional parallel dykes, southward to the Point of Ness. They reach their greatest height at the Black Craig; and either here,—at Costa Head,—or at the hill of Blotchinfield in Rousa, we must have the greatest thickness of the blue-flag formation in Orkney.

The dip to the west of the strata which on that side are in immediate connection with the gneiss at Inganess,—the dip to the north of the strata lying northward of it,— and the continuation of that northerly dip as far as Rowe, lends additional countenance to the view that the islet of primary rocks had been subjected to local elevation, independent of the general elevation which raised the whole basin of the sandstones above the waters.

Dr Clouston remarks—"On the east side of the granite, it is only the strata in immediate contact with it which dip east; for, in the course of 100 yards, they gradually dip more in conformity with the general dip of the country; but they may be seen dipping east on the shore of Græmsay, and at the point of Garsen, in Stromness; and again they dip north-east at the Burn of Cairston, and at the north-east boundary of the granite."

The strata thus dip away from the granite and gneiss on every side, unless it be on the southern extremity; and the first of Dr. Clouston's observations points *almost conclusively* to there having been an upward thrust of the granitic islet after the schists had consolidated upon its flanks.

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Taken in conjunction with the general dip of the whole series to the west, as first seen in Stronsay and last near Cairston, it shows also that the Stromness flags are far up in the series,—that the granitic reef protuded long above the waters,—just as, away to the westward, the Stack and Skerry do so still.

Now this is exactly the conclusion which has already been arrived at by Professor Geikie from a consideration of the Hoy sections, as will be noticed further on.

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NORTH RONALDSHAY.

In this low-lying island the rocks show but two varieties—the flaggy and the argillaceous.

The flags have been wrought in a quarry at the north-eastern end of the island. They are of somewhat tougher consistence than the flags of Caithness,—are less bituminous, and cannot be split into such thin slabs.

They can be raised here probably of greater size than at any other quarry in the islands.

A dressed slab, which of itself went a long way to form one side of the roof of a cottage, was found upon measurement to be 14 feet long by 8 broad, and about 2 inches in thickness.

The dip in this quarry is to the east, at a low angle; but east and west dips are equally frequent, and would in some spots at least appear to be in some degree connected with the disturbance caused by dykes which have no connection in any way with the great west and east system of western Scotland.

I was much struck by observing that the chief material of these dykes, which generally cut the strata at right-angles to the line of the dip, consisted in chief part of *limestone*,—indeed most frequently of *calcite* in large cleavable masses. So preponderating, indeed, is the quantity of lime relatively to the other material of the dykes—a soft green tufa—that it cannot be regarded as an exfiltration therefrom; and we are almost forced to the conclusion that the calcarious matter had itself been erupted in a fluent condition.

The amount and nature of the surrounding disturbance, putting out of account the adhering tufa, altogether and alone precludes the view that there are pseudo-dykes,—the result of exfiltration into a tear or cross-rent.

So interesting are the appearances, that I thought it desirable to obtain independent evidence, and I therefore requested the proprietor, Dr. Traill, to favour me with a description of one of the largest of the dykes.

Dr. Traill is a most observant naturalist, and a careful recorder—he writes:—"The position of the limestone at Howar is on the shore below high-water mark, about a quarter of a mile south of the house, or S. by E. It seems to be an erupted mass of crystalline limestone, in some parts largely mixed with fragments of the blue flagstone, through which it appears to have forced its way. Length about 65

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paces,—its direction S.S.E. by N.N.W., extending at the northern extremity perhaps half as far again in several small indistinct veins. Greatest breadth about 6 feet, but mixed with fragments of flagstone or shale, or impure blue limestone. The greatest breadth where it is comparatively pure or unmixed (calcite) is about two feet or rather more. Perhaps the average breadth of the extended mass is between 3½ and 4½ feet, but the measurements are only approximative on account of the admixture of other rocks. As I have said, it tailed off indefinitely at the north end, but at the south it came to an abrupt termination on account of the rock ending there. The position of the strata is there much disturbed."

The shelving rocky shores on the west of this island afford illustrations of the manner in which the Atlantic surges tear from their connections. and transport huge masses of rock.

The illustrations differ here in their nature from those noted in Shetland; they may not be so astounding, but they do not yield to them in instructiveness.

In speaking of the huge blocks of stone which on the coast of Shetland hang toppling on the verge of the cliff, I said that they had been *flung* there by the surge: all the circumstances of their position convey the impression of a sudden and supreme exertion of force; those to be seen on the shore of North Ronaldshay again convey the impression of transference by flotation. The first are in fact *perched* blocks,—the latter *transported* masses. The difference in the character of the shores accounts for the difference in the mode of projecture.

Here, the dip being at a gentle angle to the west, the flaggy shelves form a most perfect breakwater:—the smooth surfaces oppose no roughness, and no broken face which can receive and be shattered by the force of a blow. The curling billow, after its first crashing fall, sweeps unresisted in hissing and creaming foam, like a gradually thinning wedge, far above sea-level. The polished rock-surfaces in no way oppose the upward rush, in its vain fight against gravitation. The same gravitation which sweeps the undulation in speedy course along the ocean-level, calls back all individual particles which have transgressed the limits thereof.

As the rock is of two and a half times the gravity of water, a mass of 250 tons weighs but 150 while held in its grasp; and the tremendous pressure *a tergo* more than counterbalances the difference in gravity; so that every loose mass which presents a surface sufficiently broad in comparison to its weight, is floated off and onward, bouldering along

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the unimpeding floor, until some portion of its thickness, by protruding upward through the thinning water-wedge, has *its superadded air weight* lodged upon its shoulders, to sink and settle it upon the bottom.

No second billow, unless it be one of a greater storm or at a much higher tide, can again float it; so that of the many shifted masses upon a shelving shore, few have had more than one dislodgement and shoreward rush.

It has been assserted that there are no raised-beaches in Orkney Several localities may however be pointed out where the sea can be shown to have stood for some time at a higher level than it does at present; while there are also numerous localities which prove a no very distant subsidence of the land. Of the former of these, two exist in North Ronaldshay.

Immediately to the south of the lighthouse, there are to be observed winding trenches depressed considerably below the general surface of the island; these trenches have rough and craggy sides, their bottoms being strewn with loose stones. They bear a most perfect resemblance to the channels of lanes of water left by the retiring tide.

The other locality occurs at a point or turning of the north-west shore. Here, at some little height above high-water mark, there is a flat, beach-covered, for a space of about 100 yards in length, with huge tabular masses of rock, undistinguishable, in appearance, form, and relative position, from those which are, in the near neighbourhood, to be seen on the shore at low water.

Dr. Traill thus writes of them. "They look at first as if they had been tossed up by a mighty tempest; but as many of them were at least 10 feet long, by 6 or 8 feet broad, and 2 or 3 feet thick, I felt inclined to doubt whether it was possible that they could have been tossed up by the sea, on such a shore;—and, on examining them more closely, I was more confirmed in this doubt by observing that several of these rocks were covered with grey lichen of considerable length, particularly those masses which are nearest to the sea. From this it would appear that the sea rarely if ever reaches to so high a level, except perhaps an occasional dash of spray in winter."

On the southern side of a picturesque geo about the spot where the crags are highest, concretions, probably investing some organism or coprolitic matter, are to be found; they much resemble a potato in size, colour, and form. Their internal structure is obscure—the investing rock-layers curve round them, in infolding them.

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Jasper or a jasper-like chert is the only mineral body I have seen in this island. It apparently, from the line in which I observed loose masses of it, forms veins ruuning nearly N.W. and S.E. Its structure is very close and fine. It is usually of a bright yellow colour, with occasional heliotropic patches of a vivid green, both colours being disposed in a minute moss-like arrangement. Veins of pale-blue quartz crystals ramify through it.

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ISLAND OF SANDAY.

Apart from the occurrence of the red and yellow freestone beds on the western shore, and the conglomerate of Heclabir, the chief point of interest as regards this island is connected with a boulder of gniess which lies imbedded in the soil of a field which slopes to the east, about 200 yards west of the house of Saval, and about 45 feet above the sea.

The writer is indebted to the Rev. Mr. Fisher of the parish of Cross for sending the following measurements of this stone.

"The boulder which lies N.E. and S.W. in the direction of its greatest length is of uneven shape. It is embedded in earth to a depth conjecturally of 2½ to 3 feet. Its circumference at the level of the surrounding earth is 24 ft. 3 in.; but, as it appears to shelve out under the ground, its circumference may considerably exceed this.

Its greatest height (above the ground) is at one end 2 ft. 6 in., at the other hardly 2 feet."

It appeared to me that the greater part of this stone lay underneath the ground; and, from the slope, that if dug round its greatest length would prove to be from east to west; its greatest height is to the west.

This does not appear to be a British rock. It consists in greatest amount of white finely-striated *oligoclase*, the crystals of which are penetrated by fine filaments of actynolite,—glassy quartz in much smaller amount,—dark green finely-foliated lustrous hornblende, in well marked crystals,—very little of a pale-green mica,—a minute amount of crystals of a pale brown mineral, which may, but does not appear to be *sphene*,—and a speck or two apparently of *thorite*.

The mass also contains a single crystal of pale-green *apatite*, five or six inches in length by over an inch in width; and this apatite contains imbedded *cryptolite*. The oligoclase has occasionally the moonstone lustre.

The only Scotch rock I know which has any resemblance to this, is the gneiss which occurs, with a N.E. dip, on the N.W. slope of Ben Spinnu, in Sutherland;—this however, has orthoclase as its felspar, and does not contain apatite.

The rock has much resemblance to a Norwegian one, and, if it has been brought on floating ice, the carry most probably was from the east, or north-eastward.

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ISLAND OF EDAY.

In this Island the yellow and red upper-beds attain at the Red Head, which is somewhat more than 200 feet in height. a greater thickness than at any other point in the islands, unless it be the south shore of Scalpa Bay.

A boulder, which lies on this island, is described in the "Reports of the Boulder Committee," which are published in the "Proceedings" of the Royal Society of Edinburgh.

ISLAND OF WESTRAY.

The situation of a large stone called the Earne's Cup, was pointed out to the writer from a distance. It lay on the NNE slope of the Neuker Hill, near Pierowall. This probably is a boulder.

ISLAND OF ROUSAY.

This island consists almost entirely of beds of argillaceous flags; these attain here to a greater thickness than in any of the other islands; its highest hill being about 811 feet in altitude.

So horizontal is the bedding, so thin the beds themselves, so step-like, that it has been said that in order to walk in the island, the pedestrian would require to have a long leg and a short one.

The hills of the island, arranged in horse-shoe form, show little diversity in their rocks: at the mouth of a stream which flows from two central lakes, the rock is somewhat slabby; while at one point about a mile south of the point called Scabrake Head it is more arenaceous, the silicious grains being united by much *sideritic* matter.

At the shore below the house of Westness, it is so much jointed and indurated as to form almost a tesselated pavement.

Perhaps the finest piece of cliff scenery in the whole of the islands, though it be on comparatively a small scale, is the headland above mentioned. Here a geniculated prop stands like a flying-buttress thrown with wide-spread span apart from the main body of a mural cliff. A crush with a tilt in the bedding may be seen at the very point of the geniculation. A dyke which cuts off the southward continuation of the prop, may have had some share in troubling the stratification.*

* Mr. Gorrie seems to think that it may come to be the source of other and greater troubles, for he writes,—"There are volcanic indications about the island of Rousay, and the inhabitants need not be greatly surprised although they should find themselves and their belongings tilted up fifty or sixty yards, some fine morning before sunrise." Notwithstanding the precision of this prophecy, both as regards time and space, we would venture to assure the islanders that the foundations of Rousay are somewhat sounder than Gorrie's geology.

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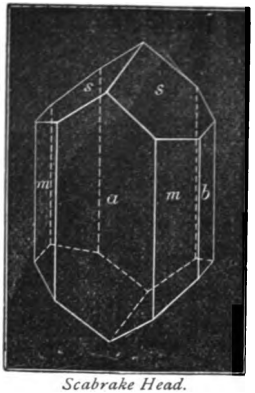

Scabrake Head.

This dyke is of a soft porphyry, which contains well-formed crystals of *augite* (H) of the size of peas, in the simple form depicted.

The hill faces, and corries about a mile north-east of this, contain *galena* in well formed cubo-octohedral crystals (H.)

Ichthyolytic schists, opposite an outlying stack called the Lobust, contain *bitumen* of the consistance of tar. (H.)

This is one of the best fossil localities in the islands.

About midway between the houses of Westness and Viera Lodge, a vein with a fine-granular barytic gangue, very similar to that of the Fair Isle, carries *malachite* with *azurite*, and apparently small quantities of *Smithsonite* and *pyromorphite*.*

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* Through the courtesy of Col. Burroughs, the proprietor, I am able to subjoin analyses of the galena and "copper ore." The first by Dr. Macadam, the second by Mr. Andrew Aitken.

The galena yielded Lead, 79·572; Silver, ·047; Antimony, ·014; Copper, ·013; Sulphur, 12·352; Gangue 8·002. As this percentage of silver is equivalent to over 16 oz. to the ton, this comes to be a most valuable ore.

The "copper ore" yielded—

Copper	3·03
Copper Oxide	3·75
Zinc Oxide	1·15
Lead	·76
Iron Oxide	5·5
Baryta	27·08
Lime	3·72
Arsenic	1·4
Sulphur	4·55
Sulphuric Acid	6·54
Carbonic Acid	9·65
Water	·60
Gangue	31·2
	98·93

This (of course presented as a mere commercial analysis,) affords hardly sufficient data whereon to speculate upon the grouping of the components. It however gives some ground for supposing that what I had from ocular inspection set down as Smithsonite, is *calamine*; and what I supposed to be pyromorphite may be the much-rarer *mimetite*.

"Concretions," similar to those of North Ronaldshay but of larger size—some singularly resembling the cast of a human foot—have been sent from this island to the Industrial Museum in Edinburgh, by Col. Burroughs.

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ISLAND OF STRONSAY.

From Dr. Neill's "Tour through Orkney and Shetland," the following extracts are made. "Upon the north-east shore of Stronsa, near the Ness of Odness, there is a very large bed of shells, which I was assured was thrown up by the sea in the course of a single stormy night about twenty years ago. The shore here is very rocky, and the people say that, till that event, it was a rarity to find on it any kind of shell. Upon examining the bed, I found that a great proportion of the shells consisted of single valves of the *arca glycimeris*, of uncommon size, twice the size of Pennant's figure of the shell. Besides the aca, I picked up many water-worm and broken specimens of *ostrea maxima*. Neither of these kinds is to be found recent on the beach.

Between the Ness of Odness and Kerbuster, there is a large bed of limestone, the inclined base of which is washed by the sea. It is of a bluish colour, but not very rich, containing probably not fifty per cent. of lime in some places; however, it is traversed by broad veins of calcareous spar. This bed of limestone lies between strata of coarse sandstone-flag, with which it is in immediate contact both above and below, though marked by a well-defined line.

"A little way from the Brough, we saw the prodigious effects of a late winter storm: many great stones, one of them of several tons weight, had been tossed up a precipice twenty or thirty feet high, and laid fairly on the green sward."

ISLAND OF SHAPINTHAY.

Many trap-dykes cut the strata at the south east end of this island, having a magnetic east and west strike. A very limpid *naphtha* (J) occurs in small quantity in some of these.

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XVIII.—*Experiments on the Elasticity of Crystals.*

By John Milne, F.G.S., Yedo.

WHEN we look at a collection of crystals we see that they can be divided into groups according to their symmetry. Thus, one group the members of which form the cubical system, have a symmetry in three directions at right angles to each other; that is to say we shall find similarly arranged planes at the extremity of three properly chosen axes. In other groups the symmetry is not so perfect. Thus, in the tetragonal system we find that the symmetry in the direction of the principal axis is different to the symmetry in the direction of the lateral axes.

When we see a crystal which seems to shew a similar symmetry in three directions, we naturally imagine that the molecules in their arrangement along these directions followed the same law. If, however, we have two directions in a crystal which as compared with each other shew differences in symmetry, we should expect that the molecules in these two directions had been arranged differently.

From what we know of the physical characters presented to us by minerals when examined in various directions, this view seems to be borne out. Thus Mitscherlich has shewn us that the dilatation of a crystal by heat has an intimate connection with its symmetry; if the symmetry is the same in three directions, the dilatation is the same in three directions, but along directions where the dilatation is different the symmetry is also different. De Senarmont has shewn us a similar relation for the conductivity of heat. The manner in which light is transmitted in different directions through a crystal depends on its symmetry, and in accordance with the laws which govern the passage of light through a crystal,we have the laws for electric conductivity. Tyndall and Knoblauch have shewn us that the magnetic and diamagnetic properties of a crystal have a connection with its symmetry. Or in short we find similar phenomena exhibited in a crystal along similar directions. Now if we accept the popular hypothesis of a crystal, that it is a body formed by the mutual attractions of molecules which are separated by an elastic medium, in order to more fully appreciate the above coincidences, we should be greatly assisted if we could shew that along the directions which in any crystals exhibit different phenomena, that there was also a difference in

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material elasticity, which probably means a difference in intermolecular space or a difference in density. The chief experiments which have a direct connection with the material elasticity of crystals, are those made by Savart, who shewed that the figures formed upon vibrating plates of crystals were directly connected with their optical axes. Lately, I have endeavoured to shew that the material elasticity in a crystal was different in different directions, and at the same time to give some idea of its relative values by bumping together spheres cut out of calcite and quartz.

As these experiments have not given definite results, because of my not being able to obtain proper materials to be experimented on, and subsequently in not being able to get these turned into true spheres, the results which I now give must only be regarded as indicating what may be obtained when similar experiments are made under more favourable circumstances.

The experiments were as follows :—

I *Series of Experiments.*

The first experiments were made with a small ball of Iceland Spar having a diameter varying between 23·7 and 23·8 millimeters, and a ball of pure quartz with diameters between 26·0 and 26·1 millimeters. The ball of calcite was placed at the lower part of a cycloidal groove. The quartz ball was then allowed to roll from a fixed point down the groove and strike the ball of calcite. This was repeated, striking the calcite each time at a different point. Although the calcite ball was observed in consequence of being struck to roll different distances, indicating that these might be due to differences of elasticity in different directions, the experiments were too crude to be worth noting.

II *Series of Experiments.*

These experiments were made with the same balls as the first, and were very kindly carried out for me by the students of the Physical Laboratory, under the superintendence of my late colleague Prof. Ayrton.

The calcite ball was fixed in a piece of wood. The quartz ball was suspended by a silk fibre as a pendulum 6 ft. $5\frac{3}{4}$ in. long, in such a manner that when it was at rest it just touched the calcite ball.

The quartz ball was next drawn back $3\frac{1}{2}$ inches and allowed to swing against the fixed ball of calcite.

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In consequence of this the swinging ball was reflected back a certain distance. This distance was observed. By repeating this experiment on several points of the fixed ball the reflection was found to be different. On the fixed ball fifteen different points were struck by the pendulum and each of these six times. The following table gives the mean result obtained for each of these points, arranged in order according to the deflection—

1.	1·54 in.	9.	1·28 in.
2.	1·46 ,,	10.	1·25 ,,
3.	1·42 ,,	11.	1·25 ,,
4.	1·33½ ,,	12.	1·25 ,,
5.	1·33 ,,	13.	1·25 ,,
6.	1·33 ,,	14.	1·25 ,,
7.	1·33 ,,	15.	1·16⅔ ,,
8.	1·33 ,,		

The points which were struck were chosen indiscriminately, but in the above table they are arranged according to the deflection.

The following are approximately diametrically opposite to each other; 1 and 2, 12 and 14, 12 and 15, 3 and 6, 11 and 12. From these it will be seen that, as might have been expected, in diametrically opposite directions approximately similar results were obtained.

A direction of no double refraction is approximately in the direction of the diameter 1 and 2.

Although it might be possible to deduce more conclusions from these results, I will not lay stress on them, as the method of experimenting was not altogether so satisfactory as could be wished, as the calcite ball between each series of experiments was refixed, it is exceedingly probable that this was not done each time in exactly the same manner, and in consequence it would not have been always in the same position to reflect the ball of quartz.

Notwithstanding this, the results are very significant of differences in elasticity.

The chief point to observe is, that in a direction of no double refraction the greatest deflection was obtained.

III *Series of Experiments.*

In these experiments, the ball whose elasticity was to be determined was placed upon a billiard table, and was there struck by another ball suspended as a pendulum.

The pendulum was a polished ball of quartz whose diameter varied between 36·8 and 36·9 millimeters. At diametrically opposite points

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in this ball two small holes were bored in which two small brass pins were placed. These were used as points of attachments for two pieces of silk thread, the other ends of which were attached to two points 60 centimetres apart, affixed to a horizontal bar of iron above the billiard table. These were of such a length that the ball hung 65 centimetres below the iron bar. Being thus suspended it could be swung backwards and forwards without any movement of rotation.

The ball which was experimented on was of calcite; it varied in diameter from 35·2 to 35·3 millimeters.

In the first series of experiments the swinging ball was drawn backwards three inches, and then allowed to swing suddenly forwards and strike the ball of calcite.

The distance to which the calcite ball rolled was then measured, when the calcite ball was struck at different points it rolled different distances.

The points taken were as follows:—

First 1 and 2. These were diametrically opposite.
3 and 5 ditto ditto ditto
4 and 6 ditto ditto ditto
7 was placed half-way between 3 and 1
8 ditto ditto 4 and 1

	Deflection in Centimeters.	Mean.	Mean.
1.	22 —22·5—22	22·1	21.8
2.	23·5—21·5—20	21·6	
3.	20 —21·5—	20·7	20·6
4.	20 —21 —20	20·5	
5.	21·5—22 —19	20·8	20·4
6.	20 —20 —20	20	
7.	21·5—21·5—21	21·3	21·5
8.	21·5—22 —22	21·8	

In a second set of experiments the deflection given to the pendulum was four inches.

	Deflection in Centimeters.	Mean.	Mean.	Mean.
1.	37—40—42	39·6	39·8	
2.	39—39—42	40		
3.	37—36—33	35·3	36·7	36·8
4.	37—41—38	38·2		
5.	34—34—34	34	37	
6.	40—40—40	40		
7.	41—36—37	38	39·1	
8.	41—40—40	40·3		

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The points 1 and 2 approximately give the direction of the optic axis, whilst the points 3, 4, 5, and 6 approximately lie in a great circle of which 1 and 2 are the two poles.

Looking at the above table we see that in all cases when the ball was struck in the direction of the optic axis, that it rolled further than when it was struck at right angles to this direction. When it was struck in the direction 5 or 6, both of which are positions intermediate to the direction of the optic axis, and the great circle 1, 2, 3, 4, the rolling was intermediate to that given by the other directions.

These series of experiments were open to several errors.

First, the ball of calcite was not perfectly spherical. However, as the points which were taken were diametrically opposite, the observations ought in part to balance each other.

Second, the line joining 1 and 2 only roughly represents the direction of the optic axis.

Third. the points 3, 4, 5, and 6, are not in the same great circle, thus 5 is nearer to 2 than to 3 and therefore we could not expect them to give the same deflection.

IV *Series of Experiments.*

These experiments were conducted in a similar manner to the third series. The balls which were used were the same as before, the calcite ball however being re-ground and being brought into a form more truly spherical. On this ball seven pairs of points diametrically placed were chosen. The diameters measured between these points and their relative distribution was as follows—

	Millimeters.	
1. and 2.	33·6 ..	Approximately the line of the principal axis of the crystal.
3. — 4.	33·8 ..	These four points were in a great circle at right angles to the line joining 1 and 2.
5. — 6.	33·9 ..	
7. — 8.	33·9 ..	8 lay between 1 and 3.
9. — 10.	33·7 ..	9 lay between 2 and the middle point of the arc. 5, 4.
11. — 12.	33·7 ..	12 lay between 1 and the middle point of the arc. 6, 3.
13. — 14.	33·7 ..	13 lay between 2 and the middle point of the arc 5, 3.

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The deflections obtained were as follows—

				Mean.	Mean.
1.	22	—22·5—23	.. .. ..	22·5	23·05
2.	25	—21 —25	.. .. ..	23·6	
3.	21	—21 —21	.. .. ..	21	20·9
4.	21	—21 —20½	.. .. ..	20·8	
5.	20·5	—22·5—22	.. .. ..	21·6	21·6
6.	22	—21 —22	.. .. ..	21·6	
7.	21	—24 —21	.. .. ..	22	21
8.	21	—19 —20	.. .. ..	20	
9.	21	—21 —22	.. .. ..	21·3	22·3
10.	23	—23 —24	.. .. ..	23·3	
11.	20	—22 —22	.. .. ..	21·3	21·6
12.	22	—22 —22	.. .. ..	22	
13.	25	—24 —21	.. .. ..	23·3	22·3
14.	22	—22 —20	.. .. ..	21·3	

In a repetition of these experiments it was found—First when the quartz ball was deflected three inches, the roll of the calcite ball was as follows:—

			Mean.	Mean.
1.	25—25—25	.. ..	25	24·7
2.	23—25—25	.. ..	24·4	
3.	20—21—21	.. ..	20·6	22·1
4.	23—23—25	.. ..	23·6	
5.	23—23—24	.. ..	23·3	23·3
6.	25—22—23	.. ..	23·3	

Secondly, when the quartz ball was deflected four inches—

1.	29—26—26	.. ..	27 28·1
2.	28—29—31	.. ..	29·3
3.	27—27—27	.. ..	27 26·6
4.	26—26—27	.. ..	26·3
5.	25—25—28	.. ..	26 26·1
6.	28—25—26	.. ..	26·3

For the total roll in diameters of the calcite ball in all these experiments, 9 must be added to each of the above numbers.

It may be remarked that points like 11, 12, 13, and 14 were the most dented by being struck with the ball of quartz, whilst the other points did not shew any signs of the blows they had received.

In these experiments it will be observed that the same general results have been obtained as before, namely, that when the calcite ball was struck in the direction of the principal axis of the crystal there was the greatest deflection.

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In any direction at right angles to this there was the least deflection, and at intermediate points deflections of intermediate values were obtained.

V *Series of Experiments.*

These experiments were made upon two balls of rock crystal, the one which was used as a pendulum being the same as the one in the last series of experiments.

The ball which was struck had diameters 36·7 and 36·9 millimeters.

On it a number of points were taken marked from 1 to 11 consecutively. The pendulum was deflected three inches, and each of the above points were struck three times.

The distances rolled by the ball which was struck are given in the following table—

							Mean.
1.	40	—	42	—	42	—	41·3
2.	42	—	43	—	43	—	42·6
3.	40	—	40	—	41	—	40·3
4.	44	—	42	—	42	—	42·6
5.	43	—	43	—	43	—	43·0
6.	40	—	41	—	43	—	41·3
7.	40	—	42	—	43	—	41·6
8.	39	—	42	—	41	—	40·6
9.	42	—	39	—	45	—	42·6
10.	43	—	40	—	44	—	42·6
11.	40	—	44	—	43	—	42·3

The following points were approximately diametrically placed, 1 and 4, 2 and 11, 3 and 6, 8 and 4.

On looking through the quartz ball at a pin hole in a card in diametrical directions through the points 1, 3, 4, 5, and 6, no double refraction was observed. In other diametrical directions through the remaining points, double refraction was observable.

All that can be said with regard to these experiments in a ball of quartz, is that it apparently shews different elasticities in different directions.

CONCLUSION.

From the above experiments it would seem to be shewn that crystals have different material elasticities in different directions. In the case of a ball of calcite, the greatest rolling effect was obtained when it was struck parallel to the principal axis of the crystal.

In a direction at right angles to this the least effect was obtained, and in intermediate directions, intermediate effects.

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Before endeavouring to shew what relations numbers such as those which I have obtained hold to the elasticity of a crystal, it would be better that such experiments were repeated by persons who have instruments, good materials, and skilful workmen at their command, which I am sorry to say I have found it impossible to obtain in Japan.

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XIX.—*On a probably dimorphous form of Tin; and on some Crystals found associated with it.*

By C. O. Trechmann, Ph. D.

THE behaviour of tin under varying circumstances has frequently attracted the attention of chemists, and several authors have concluded that it is capable of assuming at least two different crystallographic forms, only one of which, however, has been thoroughly investigated. Since Miller* described the beautiful pyramidal crystals of tin obtained by galvanic deposition from a solution of its protochloride, the anomalous appearance of those obtained in the dry way has often been remarked upon. Brooke obtained octagonal needles on slowly cooling molten tin and pouring off the fluid part. Pajott† in a similar manner obtained rhombic prisms. Stolba‡ obtained quadratic plates, whilst Breithaupt§ saw tin crystals, from Cornish smelting furnaces, which had the form of short hexagonal prisms (Miller considered them to be $Cu\,Sn^2$). Lastly Rammelsberg‖ inferred from the varying specific gravity that a not yet determined dimorphic form existed. It is found for instance that electrolytic tin with a sp. gr.=7·18, after being melted and allowed to cool, assumes the higher sp. gr.=7·29, and yet retains a crystalline structure. Whether the crystals of tin to be described below, are the same as those observed by Breithaupt and others, though probable, cannot be decided, nevertheless the observations made on them may assist in solving the question of the dimorphism of this eminently crystallizable metal.

The crystals now to be described were brought to my notice by our able secretary Mr. Collins, who writes as follows respecting them:—"I have received the crystals in question at different periods from the Rev. Canon Rogers, of Gwennap, near Redruth; from Mr. A. T. Davies, of St. Agnes; and, lately, from Mr. A. K. Barnett, manager of the Chyandour Smelting Works at Penzance. They occur in cavities of "hard head," a highly arsenical slaggy

* Phil. Mag., iii Series, 22, 263.—Pogg. Ann. 58. 660—Brooke and Miller: Mineralogy, 1852, p. 127—Rammelsb: Handb. d. Kryst. und Chem. p. 14.

† Journ. de Phys. et Chim., t. 38, 52.

‡ Journ. f. pract. Chem. 96, 178. Berz. Jahresb. f. Chem. 1865, 161.

§ Schweigg. Journ., 52, 171.

‖ Ber. d. Deut. Chem. Ges. 3. 724.

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FIG. 4.

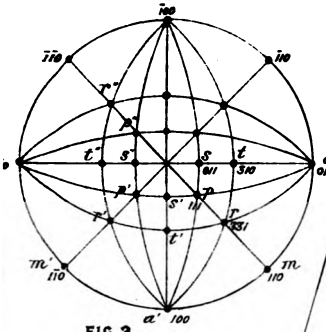


FIG. 5.

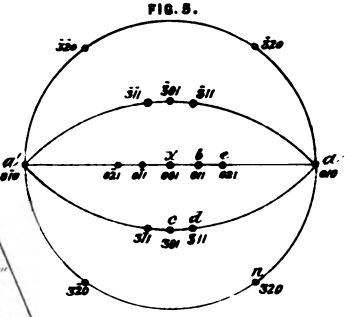


FIG. 2.

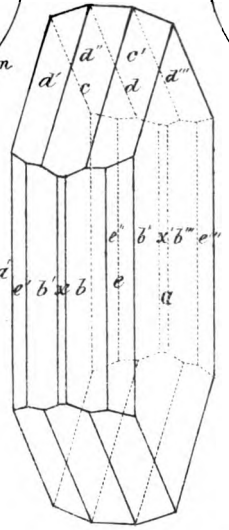


FIG. 3.

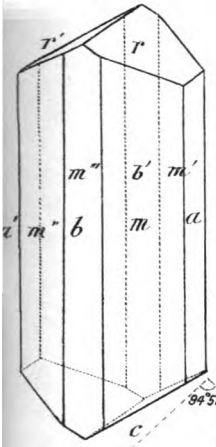


FIG. 2a.

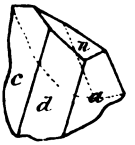


FIG. 7.

FIG. 6.

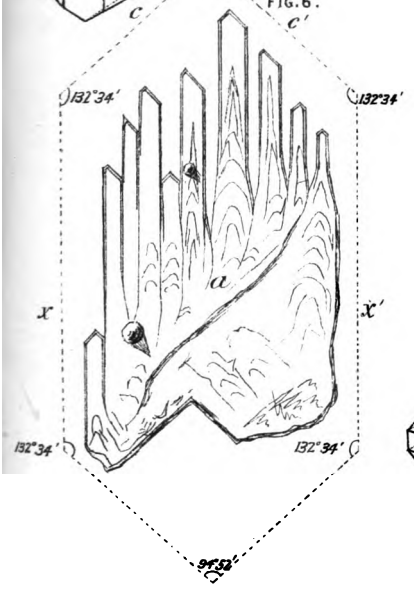
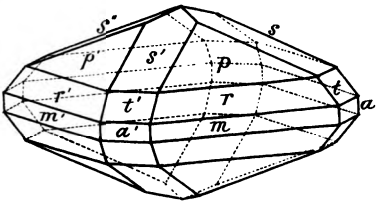


FIG. 1.



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material which is produced at a certain stage in the processes of tin-smelting. They also occur occasionally in the ordinary slags, also in cavities. They are formed with great rapidity, sometimes in a few minutes.

"In colour they vary from iron-grey to bright steel-grey, the lustre is occasionally almost exactly like that of the "kish" (graphite) formed on pigs of spiegeleisen in cooling. They are flexible but not elastic."

"When heated in a closed tube they give a *very* faint white sublimate but are not otherwise changed; in the open tube they suddenly glow, then deposit a thick white sublimate which is scarcely at all volatile on further heating; on charcoal they glow, deposit a white sublimate of oxide of tin, yielding at the same time faint arsenical and sulphurous odours, and a minute dark, brittle, magnetic bead. With borax bead the following are the results—

	HOT.	COLD.
OF	Brown, then yellowish-green	Pale clear blue
RF	Bluish	Violet-blue

In bead of microcosmic salt—

OF	Green	Very pale violet
RF	Bluish	Violet

"Treated with strong HNO_3 most of the crystals are changed to a white powder, red fumes being given off abundantly; a few minute dark crystals however are scarcely attacked after 10 days digestion in the acid.

"With HCl all the crystals are readily soluble.

"The above reactions shew that the crystals consist essentially of tin, with traces of arsenic, sulphur, iron, and cobalt.

By ordinary humid analysis the results obtained are

	a	*b*
Tin	98·7 p.c.	98·5
Iron ..	1·1 p.c.	1·0
S.As. Fe.Co.	traces	traces
	99·8	99·5
Sp. Gr.	6·5	6·4

"These analytical results shew that the crystals *taken as a whole* are composed of almost pure tin; the minute quantities of the other substances present being insufficient to form an alloy in any ordinary sense."

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Their general appearance is that of a loose and irregular mass of very thin plates of different sizes, from about a quarter of an inch square, down to almost microscopical dimensions. The colour also varies, from a dark iron or graphite grey in the larger specimens, to a light bluish-grey in the smaller ones. Single plates and crystals, as seen under the microscope, appear still lighter, approaching to a bluish-tin colour. The lustre is bright metallic, though frequently the crystals are covered with a thin dull grey or slightly iridescent crust. The crystals are brittle when strained transversely, but against pressure they seem to be slightly ductile. A lamination seems apparent in the direction of their greatest length and breadth.

Two determinations of the specific gravity were made with carefully picked and washed crystals, and gave :—

(1) Sp. gr.=6·557 Weight of crystals used 0·1659 gramme.
(2) ,, =6·525 ,, ,, 0·8274 ,,
Temperature, 60·5 F (15·8 C).

Some crystals of electrolytic tin gave, at the same time and under the same conditions :—

(3) Sp. gr.=7·136 Weight of crystals used 0·3982 gramme.
(7·178, Miller)

On closer examination of the hand specimens it is found that there are two kinds of crystals intermingled ; the first kind, the thin plates already mentioned, very greatly predominating in quantity. They are bounded by six sides, of which two are generally wanting, where the crystal is affixed to its base. Of the enclosed plane angles four approximate to 133°, and two to 95°, and the plates represent either single individual crystals, or, as is more frequently the case, the edges at the ends are replaced by a number of smaller crystals, arranged in a parallel position, thus giving the plate a deeply serrated appearance, as of a double-sided comb, and showing it to be built up of a larger or smaller number of sub-individuals. Fig. 6, plate IX, is drawn from nature, and represents one of these plates.

The crystals of the second kind are very much smaller, of a lighter shade of colour, and generally disposed on the surface of, or among, those of the first kind. The single crystals form minute prisms, which are also arranged in parallel rows—like the teeth of a comb—and held together by a thinner central part, thus forming small plates, of about 1 mm. square, with protruding points. Fig. 7 shows one of these composite forms. They are probably some combination of tin with other substances, and seem to be of a later formation than the tin 's, due probably to a change of temperature or an alteration in

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the composition of the surrounding medium. A fuller description will be given below.

Both kinds have often small globules of what appears to be tin attached to their surfaces or in their serrations.

For the sake of distinction it is proposed to call the pyramidal tin, as described by Miller, the α modification or α tin, and the first kind of the above crystals the β modification or β tin.

(1) *β Tin.* As already stated the crystals form very thin plates with prismatic habit, and are frequently built up of a number of sub-crystals. The latter (fig. 2) are exceedingly well formed, rich in facets, with sharp well-defined edges, and though excessively small are well adapted for goniometrical measurement on account of the excellent polish of their surfaces. The planes were free from striations, but the larger ones frequently showed central depressions and lines of growth, such as are seen on artificial crystals of lead sulphide or bismuth, though in a much less marked degree. Five of the best developed crystals, the largest of which did not exceed 1·5 mm. in length, by 0·3 mm. in breadth and 0·1 mm. in thickness, were picked out and measured with very satisfactory results.

System: prismatic, with angles closely approximating to those of α tin.

The following angles, the mean of the best measurements, were used for the calculation of the axial ratio (the angles between the normals are given throughout.):—

$$a : b = 68° 49·5'$$
$$a : d = 75° 19'$$

Axial ratio*:—

$$\breve{a} \quad \bar{b} \quad \dot{c}$$
$$0·3874 : 1 : 0·3558$$

(Pyramidal or α tin:—$a : c = 1 : 0·3857$ (Miller)

The observed forms were—

$a=010$	..	..	$\infty\breve{P}\infty$
$x=100$	..	..	$\infty\bar{P}\infty$
$b=110$	..	..	∞P
$e=120$	..	..	$\infty\breve{P}2$
$d=111$	..	..	P
$c=101$	..	..	$P\bar{\infty}$
$n=021$	..	..	$2\breve{P}\infty$

*In the description of the elements of a crystal we follow Groth's Zeitschrift f. Krystallographie, and designate the shorter lateral axis a, the longer one b, and the vertical axis c. This of course slightly modifies the symbols of Miller.

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They were all well and fully developed, with the exception of *x*, which was exceedingly narrow and imperfect, and *n*, which was only observed on three crystals, and determined by a single approximate measurement (Fig. 2a.)

The following is a table of the angles calculated from the axial ratios, together with some of the measured ones, and some of the corresponding angles of α tin.

Calculated.		Measured, on Crystal No. 4.		Pyramidal or α tin (Miller.)	
$a : a'$	0° 0′		0° 0·5′		
$a : x$	90° 0′				
$a : b$	68° 49·5′	$a' : b$	68° 50·5′	$s : a$	68° 55′
		$a' : b''$	68° 51′		
		$a''' : b$	68° 43′		
		$a : b$	68° 46′		
$a : e$	52° 14′	$a' : e'$	52° 33′		
		$a' : e''$	52° 24·5′		
		$a : e'''$	52° 12′		
		$a : e$	52° 15′		
$a : d$	75° 19′	$a : d$	75° 19·5′		
		$a' : d'''$	75° 21′		
		$a' : d'$	75° 21′		
		$a : d'''$	75° 16′		
$a : c$	90° 0′	(Crystal No. 1)	90° 0′		
$a : n$	54° 34′	(,, No. 5)	53° 49′		
$x : b$	21° 10·5′			s : (001)	21° 5·5′
$x : e$	37° 46′				
$x : c$	47° 26′	(,, No. 1)	47° 19·5′	t : (001)	49° 10′
$x : d$	49° 8′				
$b : b'$	42° 21′			$s : s''$	42° 11′
$b : e$	16° 35·5′				
$b : c$	50° 53·5′				
$b : d$	45° 26′	(,, No. 2)	45° 30·5′		
$e : e'$	75° 32′				
$e : c$	57° 40·5′				
$c : c'$	85° 8′	(,, No. 1)	85° 14′		
$c : d$	14° 41′				
$d : d'$	29° 22′				
$d : d'''$	81° 44·5′				
$d : e$	47° 44·5′				

The close approximation of some of the angles of β tin to those of α tin would seem to suggest that the two are morphologically identical,

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but the decided prismatic development and the peculiar physical properties make it extremely probable that we really have to deal with the prismatic system. In order to compare them one with another, the vertical axis of β tin must be multiplied by three, and the short lateral axis a placed in the vertical position, the similarity of the two axial ratios then demonstrates at once their close connection. The forms of β tin expressed as pyramidal ones, for comparison with those observed by Miller on α tin, would then be :—

β *Tin.*			α *Tin.*		
a=010	..	$\infty P\infty$	m=110	..	∞P
x=001	..	$0P$	a=100	..	$\infty P\infty$
b=011	..	$P\infty$	p=111	..	P
e=021	..	$2P\infty$	r=331	..	$3P$
d=311	..	$3P3$	s=101	..	$P\infty$
c=301	..	$3P\infty$	t=301	..	$3P\infty$
n=320	..	$\infty P\frac{3}{2}$			

Of the possible number of planes moreover only one half would be developed, and if we compare the projection of α tin upon its basal plane (Fig. 4,) with that of β tin upon the plane of the macropinacoid (Fig. 5) the absence of pyramidal symmetry becomes very apparent.

The hardness of β tin is somewhat greater than that of α tin. Cleavage very imperfect, parallel to a and also to c. Brittle to mild. Streak iron-grey, shining. The crystals melt easily, burn with a bluish-white flame, and leave a white ash. They are soluble in moderately concentrated HCl. as stated by Mr. Collins above.

The specific gravity given above is probably too low, on account of the admixture of the crystals of the second kind and other mechanical impurities.

(2.) The second kind of crystals referred to above are very sparingly distributed among the plates of β tin; they seem to be of a complex nature, though containing apparently a large percentage of tin with smaller quantities of iron and other metals, but in what state the components occur cannot be determined until a larger quantity shall have been gathered and submitted to analysis. They are hard and very brittle, with a bright metallic lustre, almost insoluble in concentrated H Cl, and do not melt in the flame, but turn black and lose their form. More correct observations were precluded on account of their minute size and scarcity.

The crystallographic properties of these crystals are, however, not without interest, and may, as soon as their composition is known give rise to interesting comparisons. For the present we can only draw

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attention to the fact that there is a close relation between these crystals and those of "iron-olivine" or artificial fayalite.

Despite their almost microscopical dimensions, the largest not exceeding 0·5 mm. in length by 0·15 mm. in thickness, it was possible to measure them with considerable accuracy.

System: prismatic.

Fundamental angles, the mean of the most reliable measurements of three crystals:—

$$m : r = 70° 45·5'$$
$$r : r' = 58° 57'$$

Axial ratio:

$$\breve{a} : \bar{b} : \dot{c}$$
$$0·9018 : 1 : 0·5652$$

Observed forms:—

a=010 .. $\infty P\breve{\infty}$
b=100 .. $\infty P\dot{\infty}$
m=110 .. ∞P
r=011 .. $P\breve{\infty}$

The following are the principal angles:—

Calculated.		Measured.		No. of Crystal.
$a : a'$	0° 0′			
$a : b$	90° 0′		89° 57·5′	1
$a : m$	47° 57′	$a : m'$	47° 58·5′	1
		$a' : m'''$	47° 55·5′	1
$a : r$	60° 31·5′		60° 31′	2
$b : b'$	0° 0′			
$b : m$	42° 3′		42° 7·5′	1
$b : r$	90° 0′			
$m : m''$	84° 5·5′	$m' : m'''$	84° 14·5′	1
		$m' : m'''$	84° 8′	2
		$m'' : m'''$	(83° 58′)	2
$m : r$	70° 45·5′	$m' : r$	70° 44′	1
		$m''' : r'$	70° 47′	3
$r : r'$	58° 57′		58° 57′	2
			58° 57·5	3

No signs of twinning were observable in these crystals, nor in those of β tin.

In conclusion, I beg to acknowledge my great obligations to Mr. Collins for kindly placing the material for this paper at my disposal, and also for making me acquainted with the constitution of the crystals.

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XX.—*Note on Abriachanite.*

By Professor Heddle.

IN my preliminary notice of this substance, I stated, upon the authority of Dr. Aitkin, that it had been supposed that it very possibly had at one time been used as a pigment in Inverness; a colourist there manufacturing a paint the nature of which he kept secret.

In re-arranging lately, a number of chemicals which had been made over to me in 1856 by my predecessor, Mr. Connell, I found a bottle with a powder of the same tint, but somewhat darker than the washed *Abriachanite*. The label of this bottle bore on it "Ultramarine made in 1841, by Murdock Paterson, dyer in Inverness."

I have not yet had an opportunity of analysing this powder, which may be merely abriachanite darkened by simple treatment with an acid.

Dr. Aitken sent me some which had been steeped in hydrochloric acid,—this had however, somewhat too much of the colour of Turnbull's blue.

I have now to announce the discovery of a new locality for the mineral.

An old limestone quarry had been during last spring found by Dr. Aitken, near the road from Inverfarrakaig to Foyers. We examined this together in the autumn. The lime-stone bed is not at all of the same nature as that so amply disclosed on the north side of Lochness, at Glen Urquhart; being fine-granular, close and firm in structure, and grey in colour.

The lime dips at a high angle to the south-east, and is bedded with the gneiss of the district, which occasionally has thin veins of quartzose massive granular *epidote* (epidosite.) Differing in this respect widely from the Urquhart lime, it carries almost no minerals: here and there a vein of pale flesh-coloured, greasy-lustred *orthoclase*, very rarely a striated felspar (*andesine?*) and a little bright, pale green muscovite with traces of epidote.

Cutting the lime, however, and somewhat in the line of its strike there is a tortuous vein of graphic granite, of a delicate pale pink colour. The quartz letterings are usually colourless, but occasionally they are of a red tint.

This granite is rent by "shakes," and in these shakes, and there alone, the *abriachanite* is to be seen *disposed only on the surfaces of the quartz letterings*, and throwing them out in bold character. While this mode of occurrence goes far to prove it to be a product of change, it is itself very singular and difficult of explanation.

The mineral is in a powdery state.

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Reviews and Notices.

On the effect produced on Mica, Gypsum, and Calcite, by the penetration of a point. (M. Reusch, *Bull. de la Soc. Min. de la France:* t. 2, p. 6, January, 1879.)—On piercing a lamina of mica or gypsum with a rather blunt-pointed needle, regularly arranged cracks are produced, having a simple relation to the crystalline axes. In Siberian mica, *e.g.* three cracks are produced, one parallel to the plane of symmetry, while the traces of the other two are normals to two of the sides of the hexagonal. In gypsum, only one crack appears, spreading a little on each side of the hole formed by the needle: it is parallel, according to M. Reusch, to a face $a\frac{9}{5}$ ($\bar{5}09$) found by M. Hessenberg, in gypsum from Wosenweiter.

If a lamina of rock-salt, gypsum, or mica be placed on a glass plate as support, with or without a layer of indiarubber, and a careful blow made with a small, very blunt-pointed punch, cracks are produced, which are analogous to those made by the needle, but they have not always the same directions. With rock-salt, the cracks are parallel to the faces of the rhombic dodecahedron.

When a lamina of calcite is placed on an india rubber support, and a wooden punch, terminated by a sort of spatula with rounded edges, is so placed on the plate that the plane of the spatula about follows a plane b^1, and a slight pressure employed, a very regular fissure is produced, parallal to $\bar{b}^1$, and crossing the whole flake without breaking it.

Similar fissures are produced with sodic nitrate. Gypsum, in flakes whose cleavage is parallel to the plane of symmetry, splits under the blow of a punch according to a plane $a\frac{9}{5}$ (509,) exactly perpendicular to that plane.

Some additional remarks on the figures produced in gypsum are made by M. E. Jannettaz, whose mode of proceedure avoids any blow. His results have been long published in various journals.

R. C. B.

On the Theory of Hemitropism, and especially that of Disthene and Grey Copper. (M. Mallard, *Ibid.* p. 9.)—It has been observed by vom Rath (in the Zeitschrift of M. Groth,) that besides the two crystalline axes which have been taken by him for the axes of the Z's and Y's,

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and which form a right angle, there is also another crystalline reticulation (rangée du reseau crystallin,) which is nearly perpendicular to the other two, and normal to the face h^1 (100); that these three crystalline axes are not axes of symmetry: and that disthene is accordingly not rhombic, but that its crystals may be studied as tetartohedrons of the rhombic system.

The author remarks that the crystallography of disthene is of great interest. If we consider the plane parallel to the twin-plane, and which contains molecules whose centres of gravity occupy the intersections of a reticulation whose meshes are parallelograms, these intersections return to the same positions when a semi-revolution is made round an axis normal to the plane and passing through an intersection. The centres of gravity of the molecules which occupy the two reticular planes situate opposite to and respectively belonging to the two parts of the twin crystal, thus hold the same relative position as in the rest of the crystal. From this explanation it appears that the macle requires a twin-plane which is a reticulation with very small meshes, *i.e.*, a plane belonging to one of the simplest forms of the crystal; and a twin axis normal to this plane. The author has shown *(Annales des Mines)* that one of the best known exceptions; the macle of orthose by hemitropism round the vertical edge g^1 h^1 (001,) not perpendicular to a simple form (law of Carlsbad,) and in which the twin-plane is not normal to the twin-axis; is due to the reticulation plane g^1 (011) of orthose evidently having a rectangular or lozenge-shaped mesh: one of the diagonals of the lozenge, or one of the sides of the rectangle having the direction g^1 h^1, brings the intersections of the reticulation almost to the same points of space, Therefore there can be—from the theory of Bravais—a twinning of the orthose round g^1 h^1, and a union of the two parts parallel to the face g^1, which is the definition of hemitropism according to the law of Carlsbad. Moreover if the arrangement of the reticulation of orthose explains the possibility of hemitropism round the vertical edge, it explains also its existence, for the mesh of the plane of symmetry g^1 being a rectangle, the two sides of the rectangle are axes of binary pseudo-symmetry.

The same considerations should apply to disthene, since its reticulation exhibits, like orthose, three evidently rectangular directions. Twin axes can and should obtain in these three directions;—(1) a straight line normal to the face h^1 (100:), (2) a straight line parallel to the intersection of the faces g^1 (010) and h^1 (100:), (3) a straight line parallel to the intersection of the faces p (001) and h^1 (100). In each of these three cases the twin-plane will be parallel to h^1. The

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first case is strict hemitropism, but the other two are hemitropes not exactly normal to crystalline faces, with twin-planes parallel, not normal, to the twin axis. These three macles have been long known in disthene, and are among the principal characteristics of that substance. Moreover it must be added that vom Rath has observed a new macle of disthene, rarer than the foregoing, about a normal to the face p, and lastly a fifth and much rarer hemitropism, about an axis normal to a face $a\frac{3}{2}$ ($\bar{3}08$.

The preceding observations, and those which the author has made previously on the hemitropism of orthose, modify and complete in one important point, the theory of twin phenomena. It is usually said that twinning takes place about an axis normal to a face, which is then the plane of re-union. But twinning can also take place about a parallel to a crystalline axis, if that axis be an axis of binary symmetry of the reticulation of a certain face; it is then a plane of re-union, *parallel* to the twin axis.

For the production of this particular hemitropism, it is enough that the twin axis be an axis of symmetry, or of quasi-symmetry. When the axis is at the same time an axis of symmetry, there is always a more or less intimate penetration of the macled crystals. In the general case, on the contrary, and when the axis of hemitropism is only a quasi-symmetrical axis of the reticulation, there is no physical reason which will permit the two reticulations to interpenetrate, and the plane of reunion is very clearly marked.

A curious example occurs in the macles of grey copper, studied by M. Sadebek. Hemitropism takes place according to two different laws: (1) the twin axis is an octahedral axis (ternary axis;) the plane of union is either a plane a^1 perpendicular to the axis, which seldom occurs, or else a plane a^2 (211) parallel to the axis, which is the general case: (2) one of the crystals has twinned through 90° about the vertical axis; the two crystals penetrate each other, and there is no plane of union. The second law has been thoroughly worked out by Bravais under the title of molecular hemitropism. The first law is easily explained. The ternary axis may be an axis of hemitropism in the ordinary sense, since it is perpendicular to one of the faces of the octahedron, *i.e.* to one of the simplest crystalline planes. This is really what obtains in most holohedral crystals of the regular system. The spinels are almost all thus macled. But one face a^2 (211) is parallel to a diagonal of the cube, and to a diagonal of the faces of a ternary axis and a binary axis: these two lines being perpendicular, the reticulation of the plane a^2 is a rectangle, one side being a ternary

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axis, which is thus an axis of symmetry. Thus hemitropism can occur about the ternary axis, with the face a^2 as the plane of reunion.

But it may still be asked why, whilst holohedral crystals, as spinel, take as their twin-plane the face of the octahedron, hemihedral crystals, such as grey copper, (*Fahlerz*) take for twin-plane the face a^2, preserving the same twin-axis. To find the reason of this difference, it must be noticed that in holohedral crystals there is symmetry in the crystalline structures on each side of the twin-plane. If P is a face belonging to the portion of the crystal which is supposed to be fixed, and P' a parallel to it; after the hemitropism, P' comes to a position symmetrical with P as regards the plane normal to the twin-axis. In these tetrahedral crystals, the face P has no longer its parallel, and if hemitropism takes place with a twin-plane normal to the twin-axis, the two portions of the crystal would no longer be symmetrical with respect to this plane. If on the contrary hemitropism takes place with a twin-plane a^2, it is obvious that the two portions are symmetrical as regards this plan. In fact the twin-axis is contained in a plane of symmetry which is common, after rotation, to the two parts of the crystal. Therefore the two portions will, after rotation, be symmetrical, with respect to a plane passing through the axis and normal to the plane of common symmetry. But this plane passing through a ternary and a binary axis, is a plane a^2.

It is evident then that if, of the two possible methods of hemitropism about the tenary axis, the tetrahedral crystals solely adopt that one whose twin-plane is a^2, it is because it is the only one which makes the twin-plane a plane of symmetry.

R. C. B.

Note on the Titaniferous Peridot of Zermatt. (M. A. DAMOUR, *Ibid*, p. 15.)—Occurs embedded in veins of calc-spar traversing the large blocks of talcose schist scattered over the southern moraine of the glacier of Findelen, near Zermatt in Valais. As in the titaniferous magnesian silicate from Pfunders in Tyrol, this peridot is of a reddish colour, like Almandine Garnet, for which it might be mistaken. Powder orange-coloured. Transparent in thin slices, and shows a decided dichroism under the polarising microscope. Its form is derived from the right rhomboidal prism. Hardness between felspar and quartz. Density=3·27. On the application of heat a very small quantity of water is disengaged, without change of colour. Infusible B.B., but blackens, and loses its transparency. Powdered and treated with hydrochloric acid, is decomposed: a yellowish powder (titanic acid) remains. On evaporation, the liquid forms a jelly. Analysis as

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follows, at (*a*,) to which is added the analysis of the similar mineral from Pfunders (*b*)

	b	Oxygen.		*a*
Silica	36·14	19·27	21·68	36·30
Titanic acid	6·10	2·41		5·30
Magnesia	48·31	19·09	20·67	49·65
Oxide of iron	6·89	1·53		6·00
Ditto manganese	0·19	0·05		0·60
Water & volatile matter	2·23			1·75
	99·86			99·60

The oxygen ratio approaches therefore 1 : 1, which is that found in peridot-olivine.

From its physical characters and constituent elements, this mineral seems to deserve a distinct place among the peridots, and the name Titan-olivine is proposed.

R. C. B.

Mechanical separation of the various Minerals of Rocks. (M. J. THOULET. *Ibid*, p. 17.) The author makes use of Sonstadt's solution of mercuric iodide in potassic iodide, the density of the liquid being reduced as may be desired by the addition of water. Illustrations of his apparatus are given, and a description of the method of using it. (Compare *Church Min. Mag.* Vol. 1, p. 23.)

R. C. B.

Anatase, from Diamantino (Brazil). (M. E. BERTRAND. *Ibid.* No. 2, Feb., p. 30)—These crystals exhibit only the octahedral faces b^1 (114): on fracture they were found to be almost entirely converted into needles of rutile: there were two very clear and brilliant cleavages, making an angle of 136°36′, a characteristic of the cleavages b^1 (112) of Anatase. This confirms Damour's observation, that the crystals known as "Captivo di cobre," are pseudomorphs of anatase in rutile. Specimens crystallographically identical, *i.e.* having only the faces b^1, come from Binnen in Valais, these are usually called Wisérine.

R. C. B.

Pyroelectricity of Topaz, Blende, and Quartz. (C. FRIEDEL. *Ibid.*, p. 31.)—The author makes his observations on a crystal whilst it is being warmed by a heated hemisphere of metal, which is placed over it, instead of on a previously warmed crystal during its cooling. With topaz he finds that a pyro-electrical axis exists perpendicular to the cleavage, and therefore coinciding with the axis of hemimorphism

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shown by the hemihedral faces. His observations appear to be at variance with those of Ries and Rose, according to whom there exists a series of central analogous poles along the axis of the crystal, and two series of analogous poles on the obtuse edges of the prism, but possibly their experiments were made on imperfectly homogeneous crystals, a condition often exhibited by topaz. Blende from Europa Point, in large slices cut perpendicular to a diagonal of the primitive cube, gives electrical tensions of contrary sign with the two opposite faces: the diagonals of the cube are therefore pyroelectrical axes. M. Hankel found that during the cooling of right-handed quartz, a negative tension was exhibited on the middle and left side of the faces p (the upper part of the crystal being considered), and on the right side a feebly positive or negative tension, or none at all. The faces $e\frac{1}{2}$ exhibit an analogous electricity, positive being replaced with negative. The prismatic faces are divided into two portions of opposite electricities by a diagonal going from the right-hand above to the left-hand below; the part adjacent to the faces p is negative: that adjacent to $e\frac{1}{2}$ is positive.

The author finds that the alternate edges of simple crystals are of opposite sign, and are the same in their whole extent. The edges of the rhombohedral faces always gave a positive tension on contact with a warmed proof plane; the opposite edges gave a negative tension. The horizontal axes of the trigonohedron, *i.e.* the diagonals of the base of the hexagonal prism of quartz, are therefore axes of pyroelectricity. The two extremities of the principal axes of the crystal present no electrical difference.

On Chromite.—(M. J. Thoulet. *Ibid.* p. 34.)—This mineral is transparent when cut into thin slices, like the ordinary rock-sections for the microscope. With transmitted light its tint is yellow, blended with red; it often shows more or less perfect sections of octahedra, and many straight or curved fractures filled with the surrounding rock, sometimes serpentinous, as in the chromite from Röros in Norway, sometimes calcareous, as in that from Negropont. The sides of the crystals lining these fissures are frequently impregnated to a certain depth with oxide of iron, giving rise to a dark, sometimes black color. Under reflected light, it has a violet-rose or greyish colour, while the spots impregnated with iron have their characteristic blue metallic reflection. This mineral is very slowly attacked by hydrochloric acid when powdered. From the result of actual experiments, it seems that it is irregularly attacked, owing to the separation of some elements in preference to others. Chromate of iron from Negropont, purified as

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much as possible from foreign matter, after a digestion for three weeks in hot hydrochloric acid, gave the following composition on analysis—

Sesquioxide of chromium	67·0
Magnesia	·4
Alumina	16·8
Protoxide of iron	19·9
	104·1

Chromite belongs to the group of spinels, where the relation between the oxygen of the base and that of the acid is 1:3; but in this case, the relation is 1:6·3, and it is evident that the mineral has been attacked by the acid. Another specimen from Baltimore gave 38 to 40 per cent. of sesquioxide of chromium. M. Fischer, of Fribourg, has already observed this admixture of oxide of iron. In the specimen studied by the author, the particles, notwithstanding their long digestion, when they were quite transparent under the microscope, still adhered to the magnet in an evident though feeble manner.

The index of refraction was obtained by placing the previously polished slice vertically in the centre of a very correct Babinet's goniometer, furnished with an apparatus capable of making a series of horizontal, vertical, and rotary motions. On the plate was directed a pencil of monochromatic light, polarised perpendicular to the plane of incidence, having traversed a Nicol with the smaller diagonal horizontal. The pencil, after reflection, is received in a microscope provided with a Nicol analyser. Examined in this manner, some substances give a total extinction, or nearly so (*e.g.*, specular iron, chromite, titanic iron, oxide of iron, &c.); others never extinguish, but reduce the brilliancy (pyrites, mispickel, galena, &c.) The former exhibit, after reflection, rectilinear, the latter an elliptical polarisation. The angles of incidence which produce either a complete extinction or a diminution of brightness vary sufficiently in the above minerals to constitute specific characters for the recognition of each. Now in transparent substances the tangent of the angle of incidence at which extinction takes place is equal to the index of refraction. The chromite gave an extinction at an angle of 64° 30′: hence its index = 2·0965.

R. C. B.

On the resistance to change offered by the faces of Crystals in their Mother-Liquor.—(M. LECOQ DE BOISBAUDRAN. *Ibid.* p. 37.)—The author finds from many experiments,

(1.) That different isomorphous crystals are not equally acted upon by a solution of one of them.

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(2.) An extremely small variation in the concentration of the solution does not cause a sudden transition from a state of very slow solution of crystalline surface, to that of a very slow deposition, but that each face remains intact, without loss or gain, in a mother-liquor whose density varies within certain limits, of small extent it is true, but still easily observable.

(3.) This resistance to change varies for each system of faces, so that a change in the external conditions (such as an alteration in the composition of the liquid, in the temperature, &c.) very often changes the relative resistances of two given systems of faces.

(4.) A mobile equilibrium does not exist between a crystalline face and its mother-liquor; a continual change of molecules does not obtain, but there is either a continuous erosion or deposition, or else—between the limits of resistance—neither.

Great precautions were taken, the experiments being conducted in a deep vault under a rock, closed with double doors.

R. C. B.

Hemihedral Forms of Alums.—(By the same. *Ibid.* p. 41.)—The author obtained an octahedron of alum with four smooth faces and four rugose, representing the union of two inverted tetrahedra. It had been obtained by immersing for some hours an octahedron of potash-chrome-alum in a slightly supersaturated solution of basic alumino-ammonium alum, giving cubes on crystallisation.

R. C. B.

Retinite, from Russia.—(M. F. Pisani. *Ibid.* p. 42.)—Under the name of manganese garnet, the author had a large specimen of somewhat testaceous structure, and in some measure polished: its colour was like that of a garnet, but its density was less, and it swelled up greatly before the blowpipe, becoming white before melting.

Density = 2·31. On analysis it gave:—

Silica	67·50
Alumina	16·34
Ferric oxide	1·16
Lime	2·20
Soda	3·92
Potash	3·88
Loss on ignition	5·90
	100·90

The somewhat testaceous structure of this specimen connects it with perlite, but its composition is rather that of a retinite.

R. C. B.

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Wagnerite from Bamle. (By the same. *Ibid.* p. 43.) The name Kjérulfine has been given to a fluo-phosphate of magnesia, containing much lime, from Bamle, in Norway. Under the name of "crystallised Kjérulfine" the author had received large crystals, up to many kilograms in weight, in rhomboidal prisms of 122°. The interior was sometimes in great part homogeneous, composed of a yellow vitreous substance, which is almost pure Wagnerite, and sometimes traversed by whitish veins, containing much lime (mixture of apatite), sometimes almost entirely formed of a whitish or rosy matter, which is principally apatite. Some crystals, yellow inside, are enclosed in a white stony crust of apatite. Hence it appears that the crystals of Wagnerite from Bamle are frequently pseudomorphs. Density = 3·12.

The analysis of this Wagnerite gave:—

Magnesia	34·7
Lime	3·1
Phosphoric acid	43·7
Magnesium	6·8
Fluorine	10·7
Residue	0 9
	99·9

These numbers agree with the usual formula of Wagnerite, and prove that Kjérulfine is not a particular species, but a Wagnerite. Moreover the prism of these crystals is the same as the derived prism $g^3 = (210)$ prevailing in the Wagnerite from Werfen in Saltzburg, where this mineral was first found.

R. C. B.

Occurrence of Gold in certain Minerals of the United States.—(M. M. CHAPER. *Ibid.* p. 44.) A discussion on the occurrence of gold in copper and iron-pyrites, and as telluride.

R. C. B.

Crystalline form of Ferromanganese.—(M. E. MALLARD. *Ibid.* p. 47.) The advantage in using spiegeleisen in the Bessemer process having been attributed to the manganese, it was sought to increase the proportion of this metal. Under the name of ferromanganese certain crystalline products are prepared, containing from 11 to 85 per cent. of manganese.

From the examination of two excellent sets of specimens in the École des Mines, the author finds that with a proportion of from 11 to 52 or 55 per cent. of manganese, the substance retains the same crystalline form, that of a prism of 112° 33′, modified by tangent

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faces on the acute angles of the prism. If the prism be designated by m (110), the modifying faces will be indicated by g^1 (100), and these last are usually very much developed. Between 52 and 55 per cent. of manganese, the crystalline form undergoes a sudden change. The structure, till now decidedly lamellar, becomes rod-like and cylindrical; the small parallel rods are hexagonal prisms with faces forming angles of about 120°, without clear terminations. They are very difficult to measure, the faces being slightly rounded do not always give clear images. The results of two measures made on relatively very good specimens are as follows:—

I.	II.	MEAN.
61° 14′	61° 20′	61° 17′
60 29	59 50(?).. ..	60 9
59 20	60 01	59 40
59 00	59 7	59 4
61 12	60 47	61
58 42	58 57	58 50

However, these measures show that the form is that of a rhombic prism of 120°, modified by the tangent faces g^1.

It is a curious point that with a continually varying chemical composition the crystalline form should change suddenly. Troost and Hautefeuille have shown that iron, manganese, and carbon form real stable chemical combinations in ferromanganese. This fact is also proved by the complete disappearance of magnetism, which takes place with proportions of manganese varying between 20 and 34 per cent. In trying to explain the permanence of the crystalline form with a variable composition, it might at first be thought that the crystals have a composition different from that of the mass whence they separate. But careful analyses made in the laboratory of the École des Mines have shown that the crystals have exactly the same composition as the mass. It must be admitted, then, that these crystals are formed by definite compounds, which unite in variable proportions, and take the crystalline form of the predominating compound.

R. C. B.

Brushes of Polychroic Crystals.—(M. A. BERTIN. *Ibid.*, March, p. 53.) A physico-mathematical essay on the theory of the "brushes" given by biaxal crystals. The substances whose optical deportment is studied are andalusite, cordierite, epidote, mica, axinite, topaz, diopside, acetate of copper, clinochlore, platino-cyanide of yttrium, and "Sel de Senarmont," this last being the salt which de Senarmont prepared in 1854, by colouring nitrate of strontia with logwood.

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"Brushes" exhibited by Uniaxal Crystals.—(M. E. BERTRAND. *Ibid*, p. 57.)—The author remarks that up to the present time brushes not only had not been observed in uniaxal crystals, but even their very existence seemed improbable. But they do exist, and in a very plain manner. The platinocyanide of magnesium crystallises in square prisms, and cleaves perpendicular to the optic axis. If a cleavage slice, as thin as possible, be held very close to the eye, a reddish-violet disk on a vermillion ground is observed, with ordinary light. With polarised light, two red brushes on a carmine ground appear, the middle line of the two brushes being perpendicular to the plane of polarisation. This is to be explained by the fact that this substance is very strongly dichroic, and a thin plate parallel to the axis absorbs all colours except red, while a slice perpendicular to the axis allows blue and violet rays in addition to pass. In fact, a somewhat thick slice, perpendicular to the axis, examined with the spectroscope, shows only the extreme red end of the spectrum, but on its thickness being reduced, the violet end appears, and absorption of the intermediate part alone obtains. Consequently if a thin plate of the platinocyanide, perpendicular to the axis, be examined with ordinary light, the rays which arrive at the eye parallel to the axis, or nearly so, will appear violet: but as the rays depart more and more from the normal to the plate, the blue and violet rays will be more and more absorbed, since they depart from the direction of the axis, and also because they traverse a greater thickness. Thus a violet disk on a red ground is seen.

The absorption of the blue and violet rays increases very rapidly in this magnesium salt, with the thickness of the plate and its obliquity to the optic axis; so that with a very small angle these rays are completely absorbed, and a very small disk is seen on a red ground. In tourmaline, a negative crystal, the phenomena are not so apparent, for a much greater obliquity in the ray is required to render the absorption manifest. It also absorbs rays parallel to the axis more than those perpendicular to it, so that it is opaque parallel to the axis, and becomes more transparent as the ray diverges: but as the obliquity of the ray increases, it traverses a greater thickness, so that the absorptive power of the tourmaline is increased.

The phenomenon is visible, with both ordinary and polarised light, in tourmaline, the coloured uniaxal micas, especially in pennine, and generally in all uniaxal dichroic crystals: but to observe it in these crystals, the plate must be inclined successively in different directions, so as to have a sufficient obliquity.

The appearance of brushes with polarised light in the case of the platinocyanide of magnesium is due to the blue rays reaching the eye

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in a direction oblique to the axis not being absorbed when these rays are in the plane of polarisation, or nearly so; but when perpendicular, or nearly so, to the plane of polarisation, they are completely absorbed. Two red brushes on a violet ground then appear, their middle line being perpendicular to the plane of polarisation.

A similar phenomenon is observed with ordinary light, when a Nicol or a tourmaline is held between the eye and the crystal. If the crystalline plate be placed between two Nicols or parallel tourmalines, the brushes remain the same, but the rings are divided into four parts. If the two Nicols are at right angles, or if the polarising microscope, or the tourmaline forceps, be employed, and the two planes of polarisation are at right angles, the black cross and rings appear on a uniformly red ground, for those blue rays which are not absorbed by the first piece of apparatus, are cut off by the second. On the analyser being turned through a right angle, the field is divided into four sectors, alternately red and violet. Pennine, Biotite, alurgite, &c., examined with the polarising microscope in converging light act similarly, when the analyser is turned.

R. C. B.

On Crystallized Chromate of Baryta.—M. L. BOURGEOIS (*Ibid.* p. 83.)—A mixture of two equivalents of baric chloride, one equivalent of potassic chromate, and one equivalent of sodic chromate, was melted at a bright red heat, and then allowed to cool slowly, when the interior was found to contain some bright prismatic crystals. They were released from their gangue by extracting with boiling water, which dissolved the chlorides. Spec. Grav. = 4·6: colour varies from fine green to sulphur-yellow. Easily dissolve in hydrochloric or nitric acid, giving an orange solution. Concentrated sulphuric acid decomposes the crystals, with formation of baric sulphate and chromic acid. Attacked by potash with difficulty, forming an alkaline chromate and baryta. The crystals contain 60·4 p.c. of baryta, and 39·6 of chromic acid: formula therefore = $BaCrO_4$. They belong to the type of the right prism with rhombic base. Angle of this prism m = (110) is 102° 11′. At the extremities of the prism and on the obtuse angles a, very small faces sometimes occur, containing an angle of about 103° 30′: on the acute angles e there are also small obscure faces, whose angle is about 114°. In baric sulphate, $m\ m$ = (110) $(1\bar{1}0)$ = 101°42′: $a^3\ a^3$ on h^1 = (102) $(10\bar{2})$ = 102°18′: $e^3\ e^3$ on g^1 = (201) $(20\bar{1})$ = 113°26′. So that the chromate and the sulphate of baryta are isomorphous.

R. C. B.

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EPISTILBITE.—(C. A. TENNE.—*Neues Jahrb. für. Min.* 840, 1879.)—The author in a short communication to Prof. C. Klein, states the results of his examination of the specimens of Epistilbite in the collection of the University of Göttingen.

The mineral is oblique, and the crystals hitherto regarded as single are really twins on (100,) which are partly contact and partly penetration twins. The plane of the optic axis lies in the clinopinacoid. The first mean line is inclined to the principal cleavage at an angle from 81° to 81° 30′.

T. D.

A NEW MICROSCOPE FOR PETROLOGY.—At our last meeting a new Microscope was exhibited, which has been specially designed for this study at the request of Mr. Rutley, of H. M. Geological survey, by Mr. Watson, of Pall Mall, who was kind enough to attend and explain its construction. By its arrangements the angles of the most minute crystals may be measured with facility and accuracy. The stage centres by means of two screws so as to revolve truly about the optical axis of any objective, and the arrangement of the polarizing apparatus is such that it may be thrown in and out of the field of view instantly, and the phenomena of plane and circularly polarized light applied to the object under investigation. There is also an arrangement for use as a stauroscope shewing the rings and interference crosses with convergent polarized light. It is furnished with graduations shewing the amount of rotation of the prisms, and also with a wedge of quartz and graduations for measuring depth or thickness as suggested by Mr. Sorby.

These arrangements are made on a plan calculated not to impair the instrument for any of the ordinary purposes of microscopy, and are so far very satisfactory.

I may mention that the diagrams accompanying Dr. Trechmann's paper, which were so highly complimented at the meeting, were (I believe) made with one of these instruments.

J. H. C.

FINNISH MINERALS.—(F. J. Wiik, *Groth. Zeits, für Kryst. und Min. Band II, Heft.* 4 *and* 5)—*Euralite.*—By this name has been distinguished a mineral of secondary formation from the Eura-Kirchspiele in the S.W. district of Finnland. It forms a dark-green apparently dense mass, which in three different sections appear distinctly crystalline under the microscope; with a radiated lamellar texture similar to pyrophyllite. H = 2.5, G = 2·62 : B.B melts readily; disolves perfectly in HCl. An analysis

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gives the following composition, from which it will be seen the mineral approaches Delessite.

	OBSERVED.	CALCULATED.
SiO_2	33·68	33·45
Al_2O_3	12·15	12·26
Fe_2O_3	6·80	6·37
FeO	15·66	16·59
MgO	17·92	18·43
CaO	1·34	1·43
H_2O	11·49	11·47
	99·04	100·00

It may be expressed by the following formula.

$R_9 R_4 Si_4 O_{29} + 8$ aq. in which $R = \frac{18}{28}$ Mg. $\frac{9}{28}$ Fe and $\frac{1}{28}$ Ca : R $\frac{3}{4}$ Al and $\frac{1}{4}$ Fe. Euralite is found in a Diabase, containing olivine, similar to the olivine diabase of Delarne in Sweden. The olivine is distinctly crystalline and contains nearly as much oxyde of iron as that of Asbyn in Sweden, according to Strüve 36·36 p.c.: the Felspar, parallelopipedon in form contains about 13 p.c. CaO: has a sp. gr. = 2·71 and is Labradorite. The Augite which exhibits a dark violet color in section has a sp. gr 3·24 and the following composition SiO_2 50·18, FeO 18·35, MgO 11·31, Ca O 19·49 = 99·33 giving the formula 3 $CaSiO_3$, 3 $MgSiO_3$, 2$FeSiO_3$.

Sillimanite (Fibrolite).—In the pegmatite granite of St. Michael, small colorless needle-like crystals are observed without terminations, strongly marked by the repeated combination of the prisms in oscillatory combinations. In polarised light these needles show that they belong to the rhombohedral system; they have a distinct fracture. Their composition like that of the Xenolite of Peterhof ($Al_2Si_3O_{12}$) gives the following analysis SiO_2 47·33, Al_2O_3 (with a trace of Fe_2O_3) 52·21 = 99·54. At Henriksnäs near Knopis a fibrolitie mineral is also found.

Titanite and *Orthite.*—At Eresby in Pargas-Kirchspiele brown titanite crystals are found in limestone of a rhombohedral-like form. The combination ∞ P, O P (110·001) gives

	OBSERVED.	CALCULATED (*Descl.*)
110 : 1$\bar{1}$0	66° 25′	66° 29′
110 : 001	65° 30′	65° 35′

In other limestone deposits of S Finnland (Kyrkslälz Mäntzäla, Karis) occurs a darker titanite of an entirely different form—namely, tabular-like, from the preponderance of an ortho-pinakoid (100) of which the following forms occur, (110), (111), (11$\bar{1}$), (112), (11$\bar{2}$), (001), (010): hence is assumed the fundamental form of Descloizeaux.

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The crystals are often twins according to (100). The following angles have been measured.

	OBSERVED.	CALCULATED.
100 : 110	= 33°	33°15′
100 : 111	= 35	35·5
111 : 1$\bar{1}$1	= 43·20	43·48
111 : 110	= 27·18	27·14
110 : 11$\bar{1}$	= 44·—	44·7
111 : 112	= 12·20	12·35

The difference in these two forms, appears to depend on the fact that the one is found in the limestone, whilst the other is surrounded by scapolite. Titanite in fact conducts itself here in a similar way to pyrites, magnetite, garnet, &c., which as isolated crystals in metamorphic schists show themselves in the simplest form, but wherever they occur in mass or in crystalline (eruptive) rocks, take for the most part the more complicated ones. This relation proves clearly the influence of external media upon secondary crystalline forms indicated by Blum, which deserves from both a geological and crystallographic point of view every consideration.

As a further proof of this influence may be cited in addition that in the limestone of Pargas the scapolite crystals have taken principally the deutero-prismatic form whilst in those of the island of Laurin Kari the proto-prismatic form predominates. In the last scapolite referred to we discover small orthitic crystals of a similar tabular form to those of the titanite crystals mentioned above. In a crystalline fragment with the forms (100:210:011, 10$\bar{1}$. 110) the following angular measurements have been made.

	OBSERVED.	CALCULATED. (*Koksch.*)
110 : $\bar{1}$10	= 70°45′	70°48′
100 : 210	= 35·20	35·8
210 : 10$\bar{1}$	= 47·6	47·50

Phlogopite.—In the greater number of the lime-deposits of S. Finnland those varieties of mica are found which occupy a position between Biotite and muscovite. Those examined have an angle for the optical axis varying from 10° to 30°, the angle lying in the brachy-diagonal section. They are not as a rule distinctly crystallised; in the Pargas variety alone is there any approximation to a distinct crystalline form, and a considerable crystal from this situation shows a combination of surfaces according to Tschermak's indication: ($\bar{1}$11) (112)—(132)—(023) (021) (001. The crystal is prolonged to a pyramidal surface and exhibits the same monoclinic aspect as the Biotite of Vesuvius, a twin striation similar to that of aragonite passes through the crystal in the direction of a surface (130).

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Plagioclase and *Orthoclase*.—Descloizeaux's optical distinction as well as the distinction pointed out by vom Rath in the application of the Pencline law have been applied in the determining the place of these in the series instead of depending as formerly on the sp. gr. The deviations of the anomalous twinning-axes as well as the optical *angle of divergence* at (010) from the angle (001 : 010) are given in degrees, from which it is to be noted that those at the obtuse angles in the direction between the corners 001:010 and 010:110 are marked with −v, those at the acute angle with + v.

	Sp. Gr.	Direction of Anom. Twin-line at 010.	Direction of Opt. Ang. of Diver. at 010.
Albite, Somero	2·622	20° (−v)	20° (−v)
Oligoclase (green), Silbole	2·643	9−7 (−v)	15−10 (−v)
Oligoclase (white), Kimito	2·664	5−4 (−v)	0
Andesine (red), Slansvik	2·670	0	10 (+v)
Labradorite (green), Logo	2·699	1−2 (+v)	15 (+v)
Anorthite (Lepolite), Logo	2·7−2·8	14−15(+v)	35−40 (+v)

Therefore the sectional directions of the anomalous twin surfaces (the rhombic section of Rath) and those of the plane of the optical axis uniformly change; so that the plagioclases form in this respect a series which would not be opposed to the theory of Tschermak

Amphibole and *Pyroxene*.—Analyses of these are here given as well as that of a Hypersthenic looking mineral.

	1	2	3
SiO_2	51·88	52·80	51·47
CaO	23·88	19·08	17·51
MgO	17·09	18·31	11·98
FeO	4·32	5·52	15·06
MnO	0·89	——	——
Al_2O_3	1·19	6·10	3·91
	99·25	101·81	99·93

	4	5	6	7
SiO_2	51·74	52·05	49·1	48·64
CaO	1·79	1·35	3·9	3·23
MgO	16·45	17·24	9·4	16·54
FeO	20·35	20·72	28·6	27·42
MnO	0·41	0·26	——	——
Al_2O_3	8·55	9·46	7·3	4·33
	99·29	101·08	98·5	100·16

1 Malacolite, colorless or lightly colored in the limestone of Wampula. —(Suchsdorff).

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2 Malacolite, green, from Javastly, sp. gr. = 3·045.—(Rengvist).

3 Augite, green crystal in orthoclase, from Helsingfors.—(Serenius).

4 and 5 Anthophyllite (rhombic) dark brown with a bluish flash of color, sp. gr. 3·022—3·045 (4 by Resenius, 5 by R. Stadius).

6 Hornblende, Anthophyllite-like (Monoclinic) fracture in the direction of the prism, cleavage in the orthopinakoid direction. Greenish black without change of color.

7 Hypersthene (?) dark green texture, radiating (F. J. Wiik).

The last named minerals from their distinct cleavages, though very similar to each other, can be clearly made out by optical means, the rhombic anthophyllite conducts itself in polarised light similar to bronzite; the hornblende (No. 6) to diallage, from which it distinguishes itself by its cleavage according to the hornblendic prism.

Similar anthophyllite-like amphiboles occur in small fragments in the Gabbro-like rock of Kurei. They are impregnated by small needle-like microlithes, brown in color and lying in the direction of the vertical axis of the mother mineral, sometimes they are light green and are then usually normal or placed obliquely to that direction. The amount of iron exercises an effect upon the crystallographic direction of the minerals. It may be remarked that the anthophyllites from Stansvik and Kurei are accompanied by an apparently pyrargyrite-like mineral derived from cordierite, epidote. A crystal from Heponselkä exhibited the following surfaces, (001), (100), ($\bar{1}$01), (101), ($\bar{2}$01), ($\bar{2}$11), (110), (210), (320), ($\bar{2}$21), ($\bar{1}$11), (011), ($\bar{3}$11), ($\bar{4}$12). T. A.

THE FORMULAS OF LEPIDOLITE.—In the article by Rammelsberg (*Monats ber. d. Berlin, Akad*, 1878) on the composition of Lepidolite it is stated at the conclusion: "Tschermak has lately employed the analyses made by Berwerth to deduce from them the composition of Lepidolite. As these analyses, with the exception of those of Zinnwald, in relation to the Lithia are incorrect, so also must the formulas founded upon them by Tschermak be so." With reference to this observation Prof. Tschermak makes the following remarks:—

Those who have read my treatise "On the chemical composition of Mica" will have remarked that in it the composition of Lepidolite is not deduced exclusively from Berwerth's analyses, but that I used all recent analyses of potash micas containing Lithia to discover the chemical combinations which occur chiefly in potash micas, whether they abound in or are poor in Lithia. If therefore in one of the analyses used by me a single quantity may not be perfectly correct, it does not follow from this that the assumed formula is so.

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As to the disputed estimation of the Lithia in the analyses of the Lepidolite of Paris and Rozena, a certain and unprejudiced judgment will be impossible, until Herr Berwerth has made new analyses.

The objection on the contrary which Rammelsberg raises against the formula supported by me may now be tested, as it rests upon the calculations assumed by him. I cite therefore the values reckoned and found by Rammelsberg, as well as those by myself, and the calculations of Berwerth, all in relation to the lepidolite of Paris.

	Rammelsberg.		T.	Berwerth.	T.
	Calc.	*Found.*	*Calc.*	*Found.*	*Calc.*
Fluorine..	5·64	5·60	5·53	5·15	5·17
Silicic Acid	50·76	..	50·90	50·39	50·77
Alumina..	28·93	28·43	28·09	28·19	28·01
Potash ..	11·93	10·89	11·65	12·34	12·78
Soda ..	0·88	0·75	0·77	..	..
Lithia ..	4·23	4·04	4·09	5·08	4·08
Water ..	..	1·12	1·30	2·36	1·36
	102·37	..	102·33	103·51	102·17

From this comparison it is apparent that my formula which Rammelsberg declares incorrect, gives quantities which agree better with his analysis than those reckoned according to his formula; farther that my formula gives a percentage of water which is wanting in Rammelsberg, though all appearances point to its being present.

In the same way the data in reference to the lepidolite of Rozena may be added

	Rammelsberg.		T.	Berwerth.	T.
	Calc.	*Found.*	*Calc.*	*Found.*	*Calc.*
Fluorine..	8·13	7·12	6·88	7·88	8·08
Silicic Acid	50·07	51·70	50·72	50·98	51·04
Alumina	28·54	28·03	27·99	27·80	28·17
Potash ..	11·19	10·29	10·95	10·78	10·28
Soda ..	1·21	1·10	1·20	..	..
Lithia ..	4·17	3·75	4·07	5·88	4·92
Water ..	..	0·30	1·08	0.96	0·91
	103·31		102·89	104·28	103·40

Here again is brought out the advantage of my formula, whilst it may be mentioned in reference to the quantity of water that Rammelsberg's method gives no satisfactory estimation.

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After having thus shown how unjust is the reproach against my formula, it may again be stated here, viz., 3 (Si_6, Al_6, K_6, O_{24})+(Si_{10}, H_8, O_{24}). With the first constituents it is also to be understood that the isomorphous Natrium and Lithium compounds are to be found. The second of the combinations cited will appear in the fluor-containing potash micas partly in the combination Si_{10}, O_8, Fl_{24}. In the estimations of Rammelsberg's analyses previously communicated as to the lepidolite of Paris the relations of the alkalies assumed are K. Na. Li as 10 : 1 : 11 for those of Rozena 6 : 1 : 7, whilst the relation of the hydrogen and the compound of fluor in both cases is 2 : 3 and 1 : 1. The estimate of Berwerth's analysis is derived from my treatise."

T. A.

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Correspondence.

Letter from Capt. Marshall Hall to Prof. Heddle, with analyses of Serpentine.

Maison Allamand, Vernex-Montreux,

Canton Vaud, Switzerland, Oct. 2, 1879.

My dear Professor Heddle,

Seeing your interest in the formation of Serpentine, I venture to send you my figures as to three analyses made by me for David Forbes, who was "on" the question of Dolomite *versus* Serpentine. The minerals he told me were,—*i.e.* the first two—close neighbours, from Cornwall. Unfortunately he died before carrying out his investigations. Both rocks (pure minerals they were not), were translucent, light-green, but serpentinic, rather than Dolomitic, gave no peroxide of iron, indistinctly crystalline (if at all), and shewed, to the best of my recollection, no specks. Of course I have not got them here.

Cornish—from David Forbes.

	Dolomitic.	Serpentinic.
SiO_2	3·43 ..	39·48
FeO, Al_2O_3, &c.	1·15 ..	1·65
(Iron, all protoxide)		
CaO	13·37 ..	24·14
MgO	20·12 ..	18·16
CO_2	49·04 ..	13·83
H_2O and loss on ignition	12·91 ..	4·56
	100·02	101·82
Sp. Gr...	2·83	2·80
Insol. in HCl.	4·53	72·314

Traces of Organic Matter

Slight Manganese reaction.

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Impure Serpentine (also from David Forbes) from Lissoughton, Galway.

FeO, &c.	2·452
CaO	5·207
MgO	38·173
SiO_2	37·332
CO	1·859
H_2O (ignition)	14·000
	99·083
Sp. Gr. (in lump)	2·50
Do. (in powder)	2·03
Insol. res. with HCl	38·010

Professor Renevier of Lausanne, is next year to bring out a book on the Vaudois Alps. M. Henri de Saussure sends me a lot of gabbros from the Saas Thal, and when I have done some work in connection with Professor Renevier's investigation, I propose to take these in hand. Next spring I want to visit the Saas Thal, which I can reach in one long day from this house, and where I have not been since 1849.

Not wishing to be a martyr to science I shall *not* go till summer of 1880. Meanwhile I hope to get the rocks to study and in part to analyse, and so be prepared to look out for the points of alteration. The gabbros (strictly euphotide) contain, I think, saussurite and diallage as principal minerals, whilst another seems like hypersthenite, and to contain labradorite (or saussurite), and hypersthene. But I am only too weak in my mineralogy, and with no chance in this healthy but un-intellectual village of bettering my knowledge. I should like to live at Lausanne, but it is so much colder. Meanwhile I should like to send half of each stone to England, get sections cut, and somebody's opinion on the contained minerals. I think I see garnet, and there is lots of schistose serpentine connected with the gabbros. If you are interested enough you could compare these rocks with the Scottish forms, only I am in a "fix" that I did not get my stones from the locality myself, and can tell but little about them till I go to the Saas-Thal. Curiously enough the glaciers have brought down specimens to the lake side here!

I only wish I could induce *you* to come out and put your rocks side by side with the Valaisan stones. Without professing much I may lay claim to such a knowledge of the country as might do some service in the way direction.

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By the bye I have not your method of silicate analysis *here*—you gave me a copy of your work—I wish it were published separately, how it would conduce to uniformity if all were to work by the same exact method, sinking small differences of opinion.

I am much exercised as to the way to estimate boracic acid. I forget if you give a method ?

Should you think anything in this letter of use for the Mineralogical Magazine pray send any extracts to it which seems unto you worth while.

Wishing you all in England and Scotland a merry Christmas two months hence.

Very truly yours,

MARSHALL HALL.

Professor M. Forster Heddle.

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Obituary.

AGAIN we have to record the loss of a Member of our Society,—a contributor to our Magazine,—and again from the ranks of the Professoriate.

HENRY How, Vice-President and Professor of Chemistry and Natural History in the University of King's College, Windsor, Nova Scotia, died on the 28th of September last, at the early age of 52.

We join with our Canadian friends in lamenting one who though a *naturalist* in the broad sense of the word, and a teacher of chemistry, was essentially and as a specialist, a *mineralogist*.

As such, even more than as a chemist, he distinguished himself in this country—as such he was received upon the other side of the Atlantic,—and as such he was labouring, and, as our own pages will show, writing, when his end came as a relief to long continued suffering.

As Professor How spent the last twenty years of his life in Nova Scotia, it is from those who were thrown into association with him there that we most fittingly must look for the truest vouchers of the worth of the man, and of the value of his work; and from the pages of the "Record" of his own University we extract the following notice.

"It was just as we were all on the eve of gathering at Windsor for the work of Michaelmas Term that the news reached us that the Vice-President of King's College was dead. Failing as his health had been for so long, we had scarcely expected so sudden an end to a life of considerable usefulness and activity. Every one who had come in contact with Dr. How had been struck with his honesty of purpose, his great love of science, his varied literary taste. From the moment he landed in this country, fresh from the wonderful laboratories of Europe, and glowing with enthusiasm for the prosecution of his favourite studies, he had lived a life of obscurity, almost seclusion. A few there were, and only a few,

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who had come to appreciate his talent as an analyst, his great learning as a chemist, his industry in fields of original research. He had come to Windsor, Nova Scotia, as the first Greek scholars of the Renaissance came to England—pioneers of new studies. The missionary who endangers his life among the Maoris or the savages of Borneo, is scarcely more worthy of commendation than the sensitive, ardent man of science, who throws himself far from congenial minds, and congenial surroundings, into the raw, though not unkindly, community of a new country. It is not right that men should deny a just tribute to those who, if they be not the martyrs, have a fair claim to be called the missionaries of science.

"Twenty-five years ago the state of education in this province was not what it is now. King's College had not then her list of scientific alumni. There was no Dalhousie College with its zeal for physical research, turning out year by year young men well equipped for work in their native country, and encouraging the ablest of them to seek the completer knowledge of Leipsic or the London Schools. The earliest form that culture took in the Canadian provinces had been that of the Oxford of fifty or sixty years ago.

"These new countries were late in putting away the bigotry of learning which lingered in their midst, often allied, indeed, with the gentle and refining scholarship of these old European seminaries, which are only just beginning to break away from the shackles of mediæval pedantry. We believe that at last physical science is beginning to obtain the paramount prominence she has fairly won, not alone by her vast discoveries in the domain of phenomena, but by quickening and inspiring generally that fearless spirit of enquiry, which, within the last few years has done so much to clear away what have long been the reproach of theology and metaphysics. Our lamented friend has done something towards this consummation in Nova Scotia.

"The place of Professor How in the history of this Institution, and of this Province is that of one who first expounded to the youth of Nova Scotia, from the abundant resources of an accomplished mind, the doctrines of Faraday, Lyell and Agassiz. It would be difficult to base a plea for grateful remembrance and respect towards a professor of learning upon more solid grounds than these.

"Although a specialist in the best sense of the term, the late Professor was also a man of considerable general attainments.

"For many years before his death he suffered much excruciating pain and accompanying depression; but his pupils and colleagues never doubted

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to the last his quick sense of the claims which others had on his consideration and courtesy, and his unwearied anxiety to discharge well his many duties as Vice-President, Professor and Librarian."

Professor How was an industrious worker;—between the years 1855 and 1876 he published twenty papers on mineralogical subjects. The style of his contributions to our Magazine vouches for his enthusiasm.

M. F. H.

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THE MINERALOGICAL MAGAZINE

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No. 16. MARCH, 1880. Vol. III.

XXI.—*The Geognosy and Mineralogy of Scotland.*

By Professor Heddle.

THE ORKNEY ISLANDS.

Part II.

Pomona or Mainland.

THE localities of geognostic interest in this large island have been referred to in the general description of the islands, and its mineralogy alone now remains to be considered.

It has been remarked above, that the muddy silts which, impregnated with the putrescent pitch of fermenting organisms, form the great mass of the flags of the "Old Red," are exceptionally barren in minerals of interest. The cause of this is not far to seek:—the components of such silts are not themselves those which go to the formation of many mineral bodies;—nor have they been subjected to the metamorphic stimulus which excites to a chemical union of ingredients and elements which lie merely in the contact of granular apposition.

Formed as they are of the triturated and granulated debris of older formations, there are to be found in them the two minerals which may be regarded as the most universally occurring in *all* rock masses,—*baryte* and *pyrite*. These are here found for the most part in veins which fill transverse rents;—and perhaps no better illustration could be given of one of

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the essential attributes of the crystallipolar force—its *selective cohesion*—than is here to be seen; namely, the manner in which it can from fa distances draw to sparsely occurring centres, so as to link together in crystalline structure the minute quantities of these two chemical compound which occur in the comminuted paste of the older or parent rock.

Small veins of these minerals are not infrequent, but they seldom show anything more than imperfect crystals.

Almost equally frequent are veins of *galena*, these also being trifling in bulk.

The first mineral to which special interest attaches is *avanturine*.

This was found by Mr. G. W. Traill* upon the shore and beneath a cliff of, I believe, the lower bed of the fiery-red freestone, noticed as forming the trough which runs through the islands.

This cliff forms the north-west corner of the Bay of Birstane, a branch of Inganess bay. The avanturine was found in small rolled pebbles. Occurring only at this spot, they doubtless were either loosened out of the cliff, or were formed by the trituration of the fragments of a band in the cliff,—but Mr. Traill could not find them *in situ*.

These pebbles were none of them of the size of a bean;—in other respects they are finer than any avanturine I have seen from Scotland. They are of that variety of the mineral in which the internal sparkle is due to flakes of mica; indeed, minute regular crystals of it are to be seen. Mr. Traill writes—"The mica is in most of the specimens arranged in layers, as it would naturally settle in a fluid, and it thus determines the cleavage of the quartz; in other cases there is no such regularity, and the mica is sprinkled about, as in artificial avanturine."

The colour of the quartz being high, the spangles approach somewhat to a golden flash, and as the quartz is not at all shivery or loose in structure, the pebbles polish fairly well,—some small ornaments made from them being not markedly inferior to the foreign stone.

Associated with the avanturine, Mr. Traill found interesting specimens of a sandstone of which the appearance is striking, and which discloses in an unmistakable manner that certain of the changes in rocks result from the action of percolating oxygenated waters.

In this sandstone a uniformly-tinted band overlies one which is profusely sprinkled with elongated spottings of a deep brown-black colour. These spottings, however, are not promiscuously disposed, nor are they in any degree uniform in size. At the line of the junction of the two bands of the stone, a multitude of minute dark specks almost eclipse the ordinary

* Author of a meritorious monograph of Quartz and Opal.

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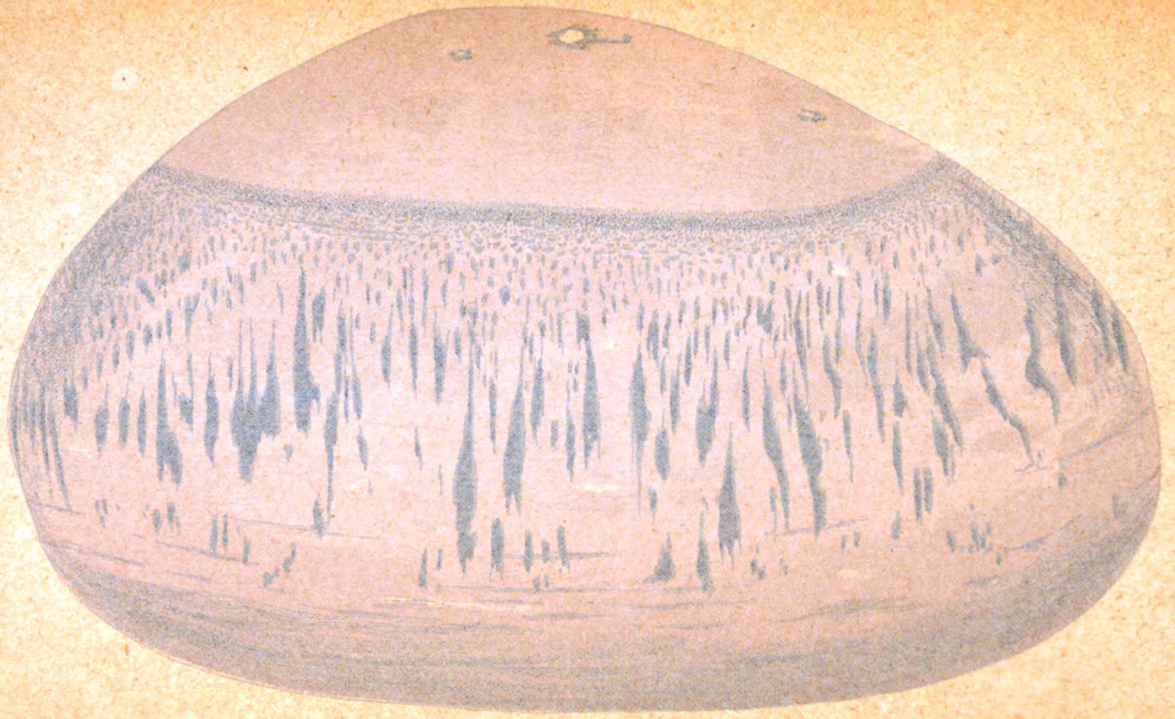

STAINED SANDSTONE — BIRSTANE BAY.

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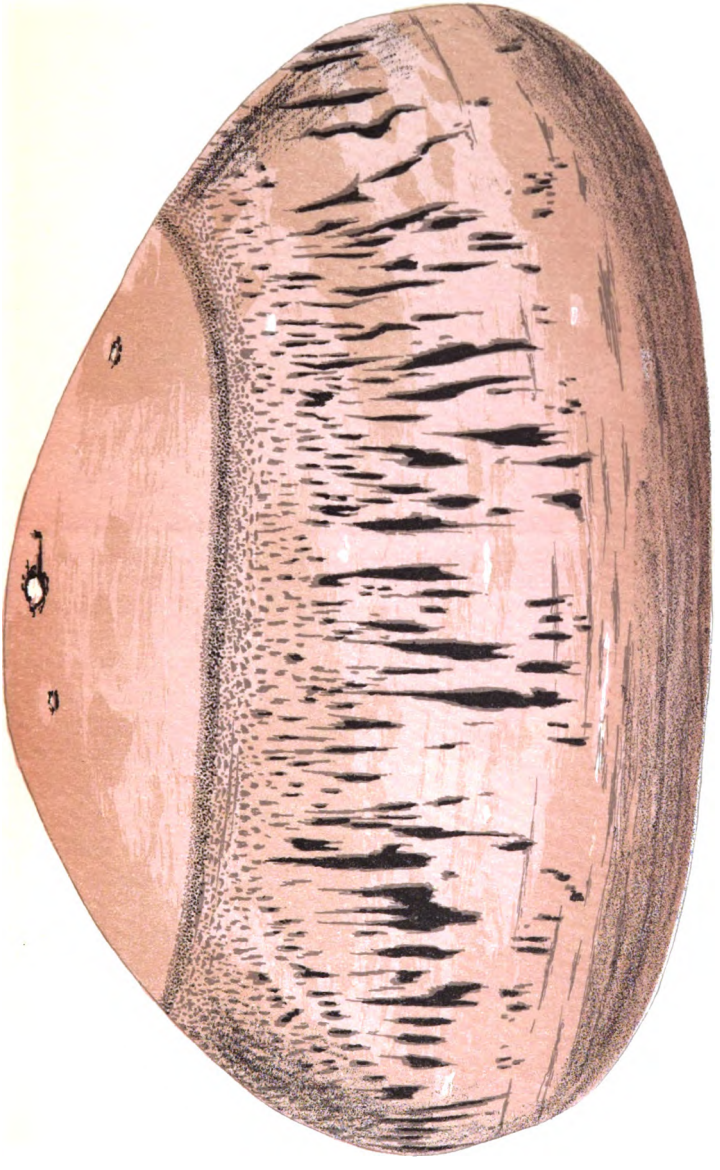

STAINED SANDSTONE.— BIRSTANE BAY.

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red tint;—from this line downward these specks diminish in number, but increase in size in an almost equal ratio, and by an almost regular progression. The long diagonal of the ovoid stain is invariably at right angles to the line of demarkation of the bands of the stone. The black markings are ovoidal in two directions at right angles to one another, and circular in cross-section.

The structure, as a whole, conveys the impression that granules of an alterable mineral were sprinkled throughout the sedimenting sand,—at first few in number, but comparatively ample in bulk; and that, as the deposition progressed, the relationship of this mineral to the arenaceous matrix, while it remained much the same in amount, altered in this respect, that the granules become smaller in size but greater in number. The ovoid stains appear to have resulted from oxidation by air-charged water soaking from the atmosphere, which carried a darkening stain downward from the changed mineral,—larger or smaller according to its bulk.

The stained portions have a manganesian or cobaltic tinge; but I have had no specimen whereon I could determine their nature. A drawing is given of the single specimen I possess. (Plate XII).

The Rev. Dr. Clouston in his excellent sketch of the geology and mineralogy of Orkney, drawn up in 1839 for the Statistical Account of Scotland, remarks—"In some places the strata have a bituminous appearance on the surface, or contain little cavities which are filled up with a soft *bitumen* or *petrolium*, occasionaly glance coal?" From the context I am led to believe that one of the localities which Dr. Clouston referred to as affording occasionally a mineral much resembling (for so I read his mark of interrogation) *glance coal*, lies about a mile north of the termination of the granitic-gneiss of Inganess. Here, at least, I found the substance now described.

It occurs in patches, generally imbedded in an inferior blue limestone, but sometimes filling thin cross-rents in the blue-flags. It is of a jet-black colour, and a high obsidian lustre. It is very much rent, so as to spring loose from the matrix in "dressing" the specimens. The fragments thus detached are smaller than peas, and have rhomboidal angles.

It sinks rapidly in water, but I had no fragment large enough to determine its specific gravity on. Its hardness is about 3. *It is soluble in benzole.*

It yielded when burnt at a red heat—

Volatile below 210°	·1	
Gas (highly illuminating)	47·82	
Carbon	51·84	
Ash	·24	H.

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The carbon or coke was very light and blebby. Unfortunately I had not a sufficiency for an organic analysis. As, however, no known mineral gives anything like the above numbers, there can be little doubt of this being a new bituminous mineral; and to it I give the appropriate name of *Cloustonite*, after its discoverer,—a gentleman whose life-long devotion to this and other branches of science, calls for—and has indeed already won for him—an honourable distinction.

Dr. Clouston notes the occurrence in the flagstone quarry at Yesknaby, of fine specimens of *dendritic pyrites*; and from Dr. Traill of Woodwick, I got specimens of the same mineral, of some size, which bore much resemblance to pseudomorphs after large radiating crystals of arragonite.

Lydian stone and *chert* also occur in association with the limestone of Yesknaby (Clouston.)

Dr. Clouston remarks upon the frequent occurrence of veins of *felspar* in the gneiss; from only two localities was I able to procure it in quantity and quality sufficient for analysis.

The first of these was from the northern extremity of the granite at Inganess. Here it occurs in exfiltrative *nodules* rather than veins, imbedded in the gneiss of the shore, immediately north of, and sometimes in close proximity to the white-trap dyke which cuts through the gneiss.

This *orthoclase* is cream-coloured; its specific gravity is 2·549.

It yielded—

Silica	63·671
Alumina	18·515
Ferric Oxide	·878
Manganous Oxide	trace.
Lime	·731
Magnesia	·307
Potash	13·536
Soda	1·798
Water	·875
	100·311 (H.)

It showed the "corded structure," described by me in the Transactions of the Royal Society of Edinburgh, and therefore probably is *microcline*.

The second of the localities alluded to, is the shore immediately west of the Point of Ness near Stromness.

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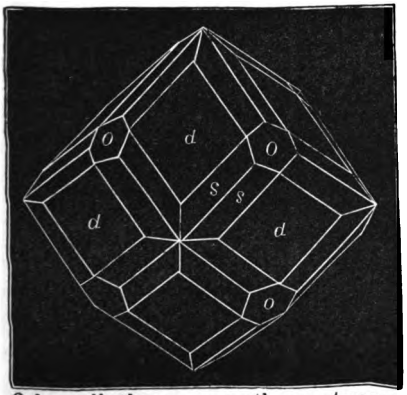
Here the gneiss is cut by many small granitic bands; but it was with difficulty that I obtained enough of the felspar for analysis. Here also it was of a pale flesh or cream colour. It yielded

Silica	60·769
Alumina	18·874
Ferric Oxide	1·318
Lime	3·747
Magnesia	·23
Potash	12·692
Soda	1·95
Water	·862
	100·442 (H.)

This felspar did not show the corded structure. It is altogether singular in composition. While it must be called *orthoclase*, yet it contains a marked deficiency in the amount of silica, and a very large quantity of lime; but as it does not in composition as a whole shade off to any of the other felspars, we cannot but regard it as a variety of orthoclase.

The granite here, but more markedly on its eastern slopes, contains *Haughtonite* (H) in very small flakes; its quartz is milky or even somewhat fatty in lustre; it does not, to the lens at least, show any oligoclase. Lithologically it differs from all neighbouring granites: it differs markedly from any in Shetland; even where most syenitic it bears no resemblance to that of Ben Loyal, and is in no way like either the Ord or the Abriachan rocks; it has, however, some resemblance to some granites of intermediate character, which occur in Aberdeen and Banff.

It passes by almost insensible gradation into gneiss.



Jameson found *garnets* in those parts of the rock which passed to mica-slate. These garnets are very small, but the form figured can be made out.

Clouston registers *rock-crystal*. He also notes the occurrence in it of small veins of *galena*; and I have myself found in the gneiss at the Point of Ness small veins of Traill's *stromnite*.

In one of the letters quoted in the preface of Low's "Tour through Orkney" there occurs the sentence:—"I beg to know what the white

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stuff was I sent. It is found *in vein* through the rocks of the Mainland.' There is much probability that this was the first observation of the stromnite.

Dr. Traill gives as the composition of this mineral.

Carbonate of Strontia	68·6
Carbonate of Lime	2·6
Sulphate of Baryta	27·5
Ferric Oxide	·1
	98·8

The locality at which Dr. Traill found the mineral was a vein which cut the flags, with about a N.N.W. and S.S.E. strike, about 50 yards westward of the Point of Ness. A breakwater now covers the spot, but at dead low-water of spring tides, specimens may still be got from the southern end of this vein.

Here the writer has obtained it, showing minute elongated acicular crystals,—the general mass having in its fracture a laminated appearance. This, taken along with the fact that weak acid dissolves out strontium carbonate, leaving sometimes a powder, sometimes a foliaceous loose mass of crystals, tends to the conclusion that this is a mere mixture of *strontianite* with baryte. Some specimens I also find to consist almost solely of strontianite.

Some minute veins of this substance may be found in the flags westward of this; and Clouston states that it also occurs in an old lead-mine, about a mile still further west.

This mine, which was worked for some time, contains cubes of *galena*. *Blende* (H.) also occurs here in double veins of about half-an-inch in thickness, and there are traces of *calamine* and *cerussite*.

Lydian Stone cuts the flags in numerous veins. *Marcasite*, (H) in cockscomb forms converted into limonite, coats the rocks occasionally.

The numerous ichthyolytes, which blacken the flags in the vicinity of the old mine, have been converted into a jetty-black brittle substance, which was pronounced to be coal by Dr. Fleming; as this substance, though of no constant composition, invariably contains a considerable quantity of phosphate of lime, such an appellation is altogether unsuitable.

A point of very considerable interest connected with this locality is the fact noted above of both the granitic rock and the recent flags being alike cut by veins not only of galena but also of stromnite;—this almost induces the conclusion that the rents had been filled from above.

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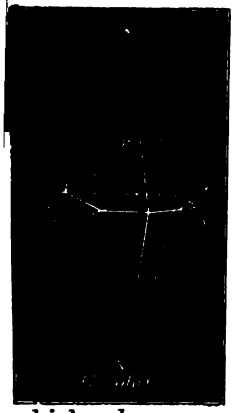

The shore cliffs which bound the north side of Scalpa Flow are rarely cut by veins of *calcite* (H); from one of these in the parish of Orphir, about half a mile west of Walkmill Bay, the writer obtained twin crystals of the form figured, of about three inches in length.

The freestone cliffs on both sides of the head of the Bay of Scalpa contains veins of lamellar *baryte*, and of *pyrite*; a vein of the latter nearly two inches in width also occurs among the rocks facing Enhallow in the west of the parish of Evie.

In this account of the mineralogy of these islands no attempt is made to enumerate the localities in which *galena* occurs, as it is, so far as I know, always trifling in amount.

As bearing on the question of the elevation of the land, it has to be noted that at Houton Head there is a small cave in the face of the rock, the mouth of which is about 90 feet above flood mark, narrow at the entrance, but widening and becoming higher towards the inner extremity, which extends to a distance of about 14 feet.

ISLAND OF BURRAY.

In Low's Tour through Orkney there occurs the following.

"Minerals and indications of mines are frequent in it (Burra); at the south side of the island was shown a sort of mineral, which Mr. Sangster told me produced lead and some small proportion of silver; but it should seem not so much as to encourage the working of it, and indeed it seems to be fuller of sulphur than of silver. At the west end of the island are plain indications of copper, and this also so easily procured as encouraged Sir Lawrance Dundas to send down a set of miners to work it; however it proved but a poor ore, and was given over. I saw some of the ore; it was but light, sprinkled over with a green matter like verdigrease. and on some of the pieces fine blue crystals of copper or vitriol. Mr. Sangster showed me some of the finer ore which was heavy and good, as also a piece of the smelted metal, which is very good and well coloured. He told me that in breaking through a crumbling sort of rock in working it they found the purest virgin copper in the appearance of leaves and sprigs of trees, according as it had wrought itself through the fissures of the stone. Where the miners dug it has all the appearance of a large vein, confined on each side by a pretty thick partition of a sort of fuller's earth which entirely separates it from the rocks on each side."

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Here we have evidence of the occurrence of native copper, *malachite*, *azurite* and other decomposed or subsesquioxide copper.

The descriptions of the vein mineralizations are very similar to that of Rousay.

In the same work we read of the Carnholm of Copinsha:—"In the enclosement point S.S.W. a quarry of a greyish marle much worn through and almost filled up with spar, but curious on account of the many beautiful figures of marcasite found between the plates. These figures are most exquisitely drawn, and represent a vast variety of weeds, few like them are to be found. They are painted of a bronzy colour, and many of them very close, even to the smallest fibres."

In Wallace's account of the Orkney Islands there occurs the following description of the fall of a meteoric stone.

"The air and clouds have, by the operation of the sun, do sometimes generate several things; as some years since, some fishermen fishing half a league from land over against Copinsha in a fair day, there fell down from the air a stone about the bigness of a foot-ball, which fell in the middle of the boat and sprung a leake, to the great danger of the lives of the men that were in it, which could be no other than some substance generated in the clouds.

The stone was like condensed or petrified clay, and was a long time in the custody of Captain *Andrew Dick*, at that time Steward of this country; and Captain *Dick*, who is yet alive, told me he gave it to the late Earl of Glencairn."

ISLAND OF GRÆMSAY.

This island shows on its northern shore between the lighthouses, a section similar to that on the north side of Hoy Sound:—a granitic nucleus with gneissic belts in each side,—these being flanked in turn by the schists, dipping on either hand away therefrom.

The only other notice I have to make of it, concerns what I took to be a dense variety of peat. This I found compacted, doubtless merely by the superincumbent pressure, in a washed out trap-dyke or deep cleft in the rock, near the summit level of the island, and towards its west side.

It seemed to me to bear a resemblance both to a dense peat which I had dug from under about 450 feet of superincumbent strata of alternating trap and peat, in the island of Tintholm in Faröe; and also to an artificially-condensed peat which is sold in London.

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The analyses of the three are as follows—

	Græmsay	Tintholm	London	
Specific Gravity ..	1·31 ..	1·27 ..	1·2	
Water	6·06 ..	9·44 ..	3·94	
Volatile at 240° ..	6·88 ..	4.16 ..	6·29	
Gas	15·52 ..	49·40 ..	56·05	
Carbon	·62 ..	20·50 ..	28·08	
Ash	70·92 ..	16·50 ..	5·64	(H)

The Græmsay substance therefore evidently consists largely of earth, and would be useless as fuel.

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ISLAND OF HOY.

In a book descriptive of the scenery of Orkney* we read—"Opposite, on the southern side, across the Sound, with its swift-rushing tides, rise the dark and precipitous hills of Hoy, which hold, as with some weird attraction, the spectator's eye. Seamed and scarred by the storms of centuries, they have an aspect of wild loveliness and desolate grandeur. The sea smiles in the sunlight, but they never lose their look of dark sublimity. In the great hollow between the heights the shadows condense into a gloom that might be felt. The effects of light and shade are profoundly touching in their almost unearthly beauty. Here and there on the lower grounds, patches of green come out vividly in sudden gleams of light, forming a striking contrast to the overhanging gloom of the weird and withered hills. The low emerald isle of Graemsay, with cattle grazing amid its pleasant pastures, lying along the waters beneath the lowering brows of the giant heights, enhances still more the wonderful effects of contrasted beauty and gloom. Wreaths of misty vapour, wafted from the wide Atlantic, seem ascending and descending the precipitous sides. No sooner has one mist-cloud drawn up its thin skirts to the topmost pinnacle and melted into thinner air, than another descends, and again the white wreaths rise seething and curling out of the gloom below. The entire view, in its fine combination of sea and land scenery, stimulates the fancy and exhilarates the heart. Seated on the Stromness side of the Sound at sunset, nothing can surpass the mingled beauty and sublimity of the spectacle when the weather-worn hills of Haa-öe loom greenly above the waters, while over their dark summits and through the great gorge between streams a silent flood of yellow light, gilding the swift currents as they glimpse out of the dark-purple shadows."

The scenery of a country is ever dependent upon its geology;—this description of towering hills with sides so steep as to throw sombre shadows over the emerald sward of one of the islands whose geognosy and rocks we have been considering, points unmistakably to an overlying series of rocks; while the contrasted appearance presented by these hills with that of the general aspect of the lower lands indicates, at least, an altogether different formation.

This upper rock consists of a series of beds, which attain a thickness of about 1300 feet. Throughout the whole of this thickness they are of the

* "Summers and winters in the Orkneys."—Gorrie.

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nature of freestone; in the lower beds micaceous, and with included masses of decomposing shale, flag, or perhaps mica slate; in the upper showing little else than feebly agglutinated grains of sand:—indeed, a deficiency of cement is the marked feature of the rock throughout.

Yellow colours with an occasional tendency to red tints prevail.

It was probably their colour and soft or loose structure, as much as their superior position, which for long led to their being considered to belong to the New Red Sandstone: Jameson, however, was not so far astray as was at first imagined, when he indicated that he did not think that they were far off from the Coal Measures.

These thick-bedded and coarse-grained rocks are in no part of the island of Hoy conformable with the flags of the Old Red. A fringe of the latter occurs both in the north-east, and in the eastern and southern shores of the island, and there are several points where the relationship of the one to the other is disclosed. At one or more localities, moreover, an igneous rock is interstitialised between them. The occurrence of this igneous rock had been noticed by Wallace and by Jameson;—the latter says, "in many places I observed a rock of wacken,"—but its position and relation to the other rocks was first pointed out by George Anderson, and by Dr. Clouston.

Anderson, in the first editions of his "Guide to the Highlands," writes: "All the deposits now enumerated are traversed by numerous dykes, veins, and beds of trap-rocks. The base of the "Old Man of Hoy" consists of an irruptive porphyry rock, supporting an isolated crown of sandstone on its top; in the south-east side of the same island, at Walls, a mass of amygdaloidal trap extends nearly 600 yards along the coast."

Dr. Clouston writing in 1839 (Statistical account of Scotland) says,—"These secondary strata (the slates) may be found at all inclinations, from horizontal to perpendicular, but in general they dip to the west, at an angle of about 20°. III. *Sandstone.*—To understand the position of these rocks, it is necessary to trace them to Hoy, where the sandstone rests upon the slates. This sandstone is easily decomposed by the action of the sea, and forms numerous caves and fantastic forms along the precipices where it occurs, of which the insulated rock called the Old Man of Hoy may be given as an instance. This singular rock is formed of the same strata as the precipice from which it is disjoined; and as this is nearly 1000 feet perpendicular, it affords a magnificent exhibition of the strata. The top is red sandstone and the base on which it rests amygdaloid. The only place where I know of trap overflowing the secondary rocks is one which I discovered about twelve years ago, in the west side of Hoy, where there is a bed of it fully 100 feet thick, and, I believe, several miles in extent. Near the same bed, on the sea shore near Rackwick, I also found a fine vein of fibrous gypsum."

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A nephew of the writer's found this bed high up in an almost inaccessible portion of the precipice of the Kame, immediately above a spot where the unconformability of the yellow beds to the underlying flags is admirably disclosed,—thus proving its extent to be, as stated by Dr. Clouston, "several miles."

Lastly, Professor Geikie has, in his classical paper upon the Old Red Sandstone, founded strongly both upon the unconformability of the upper rock, and upon the intervening igneous platform, in insisting upon a separation of the two sets of beds,—a separation which he makes more absolute in his Geological Map of Scotland, by removing these upper beds altogether from an association with the Old Red, and placing them in line with and at the bottom of the Coal Measures.

In so doing, Professor Geikie has retained the Old Red colouration;—but, following in his track, the writer has, for the sake of consistence, adopted in his map of the island Geikie's Coal Measure tint.

These upper beds of sandstone, then, have nothing in common with the flaggy silts upon which they lie. They differ from them in composition, and in included minerals,—they are altogether discordant with them in dip, and a great igneous sheet, indeed, (as Geikie shows,) two sheets, had been poured out over the flags, and had been solidified, before the sand-grains of the upper rock settled to their place. An enormous period of time, indeed, had intervened between the cessation of the deposition of the true "Old Red" and the commencement of the formation of these rocks. Though it is probably the upper beds of the lower formation upon which they rest, still these beds had been solidified, raised above the waters, and denuded to a great extent, ere ever the volcanic fires had poured that massive sheet over their abraded edges; and what period had elapsed before the dry land had again been submerged and the first grains of sand, borne from the waste of an altogether diverse parent-rock had settled upon the bottom of the new oceanic lake, we have no means of judging. The organisms of the past had, for the most part, ceased to exist; another day in the creative progress had dawned, and almost all things had become new.

The want of cement in these upper sandstones has been noticed:—this, their most marked feature, renders them exceedingly friable, prone to disintegration, and readily subject to aerial waste; streams cut their channels here with ease; the ocean waves cut and carve at them at will; and the old glacial mantle has scalped their summits into rounded contour.

A single central bed of about 60 feet in thickness has somewhat greater closeness and compactness of structure; it shews itself in the

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three northmost hills; and, from its cleaving by cross-joints into rude parallelograms resembling somewhat the head of a hammer, it has given to the most southerly of these hills the quaint name of The Hammers.*

The general dip of these beds is to the S.S.W.

The amount of waste of this rock along the ocean verge is enormous,—Five of the hill ranges,—the Coolax, (? *Coolacks*) the Black hill, Melfea, the Snuke, and the Bery—have been cleft sheer off; forming precipices which are nearly mural, and from 600 to over 1100 feet of perpendicular height. Nor, indeed, are the rock-shores which intervene between these ranges of so greatly smaller altitude as to prevent the coast as a whole from presenting the appearance of an almost unbroken wall,—a rampart of towering stone of almost unrivalled grandeur. No one of the individual cliffs, however, can compare in lightness and in elegance with those either of Foula or St. Kilda; the heavy beetling mass of the somewhat higher hill-ground in the back, giving to all except perhaps the Bery and the Snuke, somewhat of the aspect of *a bluff*; and much diminishing the apparent altitude.

One of the detached stacks, however, the far seen and further famed "Old Man of Hoy," stands pre-eminent—*facile princeps* of all in Britain.†

From the abruptness of the truncation of the strata of this upper sandstone, and from its altitude, the view to be obtained from its summit is both panoramic and almost overhanging.

Gorrie, whose power of scenic description is far in advance of his geology, says of the view from Hoy Hill—"Now we stand upon the bald crown, and lo! the whole Orcadian Archipelago, with its islands, holms, stacks, and skerries, lies at our feet like the scattered fragments of some parti-coloured toy-map. It would be difficult to match the spectacle in unexpectedness of scenic effect. There is in it something dreamy, aërial, mystical, unreal. We seem to be looking down upon isle and islet, cape and bay, from the car of a balloon, or the balcony of a lofty tower."‡ This

* Two of these hammer heads have become dislodged, and have fallen into a glen;—one of these having been hollowed out into small chambers, probably by idle hands, is now known as the Dwarfie Stone.

† Gorrie says: "This rock is a huge primeval pillar, standing out from the line of cliffs;—heedless alike of calm and storm, the Old Man of the Sea, like a grim and veteran sentinel at his post, keeps silent watch and ward amid the lonely waters."

So far from being a *primeval* pillar, however, it is formed of much the *youngest* rock in the islands; and so far from being heedless of the storm, one of his limbs lately gave way during a storm, and the "grim sentinel" is now on his last leg.

‡ The sunset view from the summit of Hoy Hill has lately been described in the following lines:—

"Stretched like a map the prospect lies
In varied beauty far and wide;
There, Orphir's green acclivities,
There, Pentland with its raging tide.

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description is happy, markedly so in the last line:—but this line shows that Mr. Gorrie had never stood upon the pinnacle of steep Suilven, or he would have reserved his last comparison for that lighthouse-like hill.

Dr. Clouston conceives that this upper sandstone is cut by dykes, and instances the cleft of the Green of Gair as having originated in a washed out dyke. This is nearly opposite to the amygdaloid of the Burn of Berridale; and the occurrence of loose agates on the hill-tops is also strongly confirmatory of the supposition.

The flags in the north end of the island dip persistently directly from the primitive rocks of Græmsay, and maintain this dip till they are encased by the huge enveloping masses of The Hammers, Hoy Hill, and The Coolax. Where overlaid, however, by the towering rocks of the Kame, the dip is to the south west; and as, where they are exposed by sea-scalping in the indentation near the Old Man, they are dipping to the east and south east, there must be a fold under the sandstone of Hoy Head.

In the south end of the island there are many folds; along the east shore these and the dips are inconsiderable; but in South Wales the dip is persistently to the west of north. In the peninsula of Brims, which is probably faulted on both sides, the dip is high; the beds are pronouncedly separated from one another, and a rugged and uncouth line of serrated precipices is the result.

Immediately to the westward of this, there is a great fault, which probably runs continuously northward to the eastern foot of the hill of Melsetter. West of this fault the upper sandstones come in, in the detached mass of the Old Head,—a bold promontory of 150 feet in height, which, faulted on both sides, has its basement strata thrown down below the level of the flags. A dyke succeeds to the fault upon the west; fault and dyke together forming the artificial looking boat-harbour of Sandsgeo. To this a large mass of purple-coloured amygdaloid succeeds.

There is again faulting, succeeded by slabby and micaceous beds of the sandstone, which form the coast-line till they are overlaid by the

---

Ben Hope's huge dome of mystic blue
Looms from afar in form sublime,
Ben Loyal and coned Morven too
Eke out the splendours of the line.

The distant Klibrick rears its peak
In azure tints which melt to sky,
And the grim Griams' contours seek
With varied form to charm the eye.

And Rath's grand capes, mid skies of gold,—
Fit setting for that sapphire crest,—
Their splintered pinnacles unfold
To spangle in the blazing west."

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towering and steep-sloped mass of the Bery Head; this, with the much lower Dunnet Head on the Caithness coast, forms the jaws of the Pentland Firth.

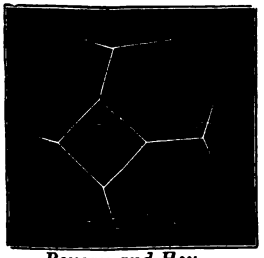
Geikie discovered in Hoy two of the throats of the igneous out-flow; and in South Walls another apparently occurs at the Burn of Simmary; while there are several veins or masses of tufaceous mud, now very serpentinous and decomposed, at the south-west end of the Bay of Melsetter.

A mound, grass clad throughout, which stretches across the mouth of the meadow of the Kame, has much the appearance of a terminal moraine. The hills, both of the lower and of the upper formation, exhibit well marked glacial contours.

We have in this island to consider the minerals of the flag formation, of the sandstone, and of the igneous rocks.

Minerals of the Flags.

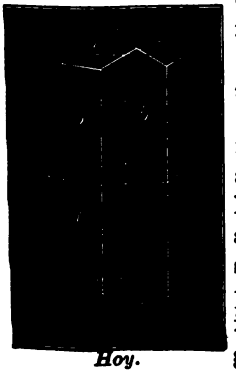
Hoy.—At Selwick there is an old lead mine; it would appear to be the continuation of the vein on the opposite shore of the Mainland. The *Galena* from this vein was said to contain 46 ozs. of silver to the ton. It is rarely in cubo-octahedral crystals.



Rousay and Hoy.

A little north of this, the smooth face of a cliff which faces about due north, is covered with crystals of about an inch in length of *calcite* in the twin-form figured. There are also rarely veins, with crystals of the second form drawn, *b*, *p*, *k*.

A little north of the Manse of Hoy, two veins of *limonite* were worked for some time. These veins run nearly north-west and south-east. The ore is in the botryoidal form, and so dense that the fibrous structure is obscure; it is dark-brown in colour; and is apparently somewhat stained with *reddle*, which occurs in the rock matrix.



Hoy.

Walls.—The flags of this southern part of the island, though they do not contain so many fossils as those at its northern extremity, are in certain localities highly charged with bituminous matters; and those flags which are so charged invariably show upon their surfaces slickenside or friction polishing, of a contorted and grooved nature; as if there had been frequent twistings and rubbings going on among them.

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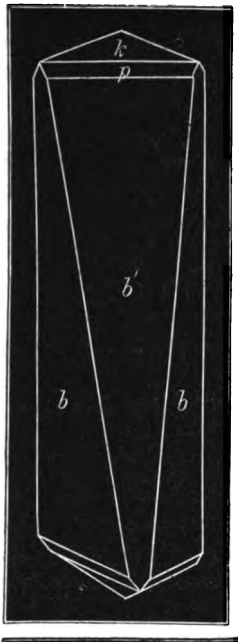


Localities where such dark flags abound, are the little Bay of Osmondwall, and a little west of the South Ness, in South Wales. At both of these localities the dip is to the N.N.W. at low angles.

A specimen of the Osmondwall flag yielded—

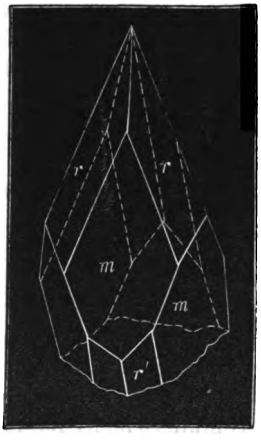
Water	3·11
Gas..	17·61
Carbon	5·936
Ash	73·044 (H.)

Mr. Low states that out of the "burrows" there used to be got "beads made of a sort of Lithandax or Parrot Coal, which burn in a candle leaving white ashes, after a very bright white flame."

These beads probably were made from the above flags.

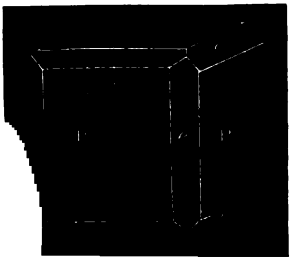
We here see that the term "Parrot Coal" was in use in 1774.

Probably it was the occurrence of these bituminoid flags which led Jameson and others to entertain the hope that coal would be found in this part of the island. There can be little doubt, however, that the hydro-carbon which impregnates the stone has had its source in animal organisms.

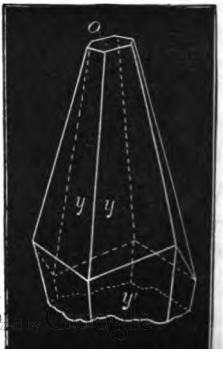


On the east shore of Aith Hope there is a vein which yields specimens of *red hematite*—this occurs in stalactites which have a hollow core.

At about the centre of the Peninsula of Brims there is a small drained lake, the bed of which is composed of marl; the cracks of the rocks which intervene between this and the sea are filled with calcite. From one of these veins *calcite* in small crystals of the form *m r* that of the figure may occasionally be got.



The flags which are in the immediate vicinity of a "neck" of tufa which has penetrated them at the Burn of Simmary, contain vesicles filled with tarry *bitumen*. Other cavities and veins in the vicinity contain *pyrite* in the form *Pe*; crystallised *calcite* also occurs in the form *y o*.



Minerals of the Sandstone.

At this south west extremity of the *cul de sac* called the Meadow of the Kame there are two clefts in the rock, by means of which the cliffs may be scaled. Lining the sandstone of the southern of these, *psilomelane* is rarely to be found.—(H).

Lumps of *reddle* are here also to be met with.

A little west of the highest point of Hoy Head, there is a turret-like projection called Braebrough; this, which is the most mural point of the whole cliff, is almost isolated; indeed it is attached to the main line of cliff by merely a narrow neck of lower altitude.

Here Dr. Clouston found a vein of *psilomelane*.

The face of the main cliff upon the right hand of the neck where it faces Braebrough, is covered with crystals of *limonite*, pseudo. after pyrite; it is in the interesting form drawn.—(H).

About three hundred yards further south, a locality called Lead Geo is reached.

George Low, writing in 1774, says,—"The ores of iron in Hoy are of two kinds, and found in great plenty in two different places. That dug near the Kirk is Hematites. * * * Another kind may be had in vast quantities from Hoy Head, where it runs in many regular veins in the very brink of the sea rocks. This is blacker than the former to appearance, it is much more solid, and weightier, looks as if it had been once in fusion, and had settled in a number of bubbles, which I dare say had not been the case: its first formation is from an infinite number of small particles or drops adhering very firmly together, and growing still more solid as they imbibe more of the iron, till at length it becomes a flint-like mass of the colour above described. Some years ago a company of adventurers from London dug several tons of this last, which they imagined was an ore of Cobalt, but without foundation. They sent several specimens to London, but how it turned out I could never learn. The work, however, was given up. When Mr. Banks was in Orkney on his way from Iceland, he took a step to this mine and smelted a piece of the ore, and assured me of its being iron."

As the ruins of a turf hut are to be seen here, and as the writer found a buried deposit of about four hundred-weight of the ore, near to where there were evident signs of working, there can be no question

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that this is the locality alluded to by Low; and, as no galena is now at least to be seen here, the following extract of a letter of Mr. Low may probably explain the name of *Lead* Geo. "Has not your friend* perhaps something mistaken the words of the historian with respect to the black and white lead (*Plumbum album et nigrum*) Buch. History? I have never heard of black lead or "Wad" to be found here, but common lead in many places."

Tne common confusion between *wad* and *graphite*, taken along with the manner in which the hands are soiled in working among the ores which occur at this spot, doubtless led to the adoption of the incorrect name.

The ore described by Low is however not one of iron, but is for the most part *psilomelane*; his "flint-like mass" is a very dense *wad*. There is it is true a small quantity of *limonite*, but not enough to explain the extraordinary statement as to iron having been smelted *upon the spot* apparently,—for so the language used would imply.

Low's description of the ore is most accurate, and, as it will be seen, most suggestive and shrewd.

The veins are situated about 200 feet below the summit of the cliff, here called 1130 feet in height.

There are three or four veins still to be with difficulty seen, for the working has, from the precarious footing and the danger of the position, been of a rough and destructive description.

The appearance of the *psilomelane* varies in each of the veins; it occurs in finer masses here than at probably any other known locality.

In its commonest and least interesting appearance it presents itself in mammilated masses with an obscure fibrous structure and a dull lustre. Of this variety the specimens merely as such are the finest. Such masses sheath the sides of the vein and any loose or projecting processes which may occur in its vacuous centre. Though the surfaces of these mammilations are dull, and so soft as to soil the hands, they may when dry be polished by friction; but, when wet, the mineral may by brushing be diffused through water to a large extent.

There is therefore in these specimens a certain approach to *wad*.

Another appearance, though a rare one, is in large flat sheets which possess a mirror-like lustre, and have little trace of fibrous structure.

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* *Pennant.* Mr. Anderson, in his introduction to Low's work, very clearly shews the *vampire character* of Pennant's friendship for Low.

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In another vein it is of an exceedingly peculiar appearance, resembling a quantity of wires, of the thickness of needles, laid longitudinally together. The wires can be separated from one another with perfect ease—they pass transversely from side to side of the vein, which is about eight inches in width.

Another vein is of the nature of a dense *wad:* it is about two inches in width, is devoid of structure, if it be not of a granular description, and it breaks with a well-marked conchoidal fracture. This therefore is probably Low's "flint-like mass."

There is one marked fact which is to be observed of all these veins, it is that at their sides, the yellow, loose-grained sandstone-rock is stained by the manganese in a manner which forcibly conveys the impression that the ore did not *exude* from the rock into the vein-rent; but was *poured into* the rent, and soaked to a small extent into the porous stone: the limit of the stain is a sharp line of demarkation, it does not shade off with a fainter tinge, to the smallest extent.

I have said that *limonite* is associated with the psilomelane,—it is so associated in two of the veins only, and its appearance in them is very dissimilar.

In both it is superimposed upon the manganese, but in the one it assumes, or rather attempts to assume a minute stalactitic structure, sometimes passing into a pseudo-fibrous or knitted appearance. The coating of limonite however, which does this, has in itself the usual divergent-fibrous growth; the fibrous surface is of a purplish-brown colour, and it has a certain amount of the tremulous half-scaly appearance of lepidockrokite. But the chief feature of this variety of limonite is that its surface, which is dull, has invariably a greenish to an ochery tint.

This variety had a specific gravity 3·684, and yielded—

Ferric Oxide	78·787
Ferrous Oxide	3·236
Manganous Oxide	·153
Alumina	·56
Lime	·472
Silica	3·067
Water	14·314
	100·589 (H)

When dissolved in cold hydrochloric acid, a small quantity of light flocculent silica separates; upon applying heat this went entirely into solution.

The silica therefore is in combination.

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The second variety of limonite I found directly coating the sandstone, in one or two specimens; usually it coats the botryoidal psilomelane, and, being a coating of uniform thickness, it assumes the botryoidal form of the under-lying mineral.

The surface of this variety is highly polished—jet black, and splendidly lustrous. Its internal structure is divergent-fibrous but it is tough. The internal colour is purplish-brown, and the lustre satin-like to vitreous. Its powder, however, is of a very rich ochre-yellow.

It yielded—

Ferric Oxide	82·135
Manganous Oxide	·343
Lime	·571
Magnesia	·214
Silica	3·315
Water	13·87
	100·468 (H)

Here also the silica was in combination.

The thickness of the coatings of this variety of limonite vary from about the fourth of an inch, to films of extreme thinness—these can always be recognised by their brilliant lustre, and of course by their ochre streak.

Of the *psilomelane* I analysed the massive sub-fibrous variety.

Its specific gravity is 4·607. It yielded—

Manganous Oxide.. ..	66·995=MnO, Mn_2O_3 71·868
Cobalt Oxide	1·478
Magnesia	·098
Baryta	14·876
Potash	·5
Soda	·003
Oxygen	6·658
Water	6·051
	101·484 (H.)

The vein which I have considered to be a dense *wad*, had a blue-black colour, and a brown streak.

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Its specific gravity is 4·4. It yielded—

Manganous Oxide	64·87 = MnO, Mn_2O_3	69·58
Cobalt Oxide	1·995	
Magnesia	·199	
Baryta	14.97	
Potash	·247	
Soda	·259	
Alumina	1·097	
Silica	·898	
Oxygen	5·521	
Water	5·688	
	100·454 (H.)	

When this variety is steeped in water and then left to dry, a saline efflorescence exudes from it, which is chiefly a salt of potash; as the specimens had been washed, and also had been buried in wet earth for a century, probably most of the alkalies must have been lost before analysis.

These analyses show that the "London adventurers" were not altogether wrong in conceiving the mineral to be an ore of cobalt.

They also show a most peculiar antagonism to exist between the two closely chemically-allied metals—iron and manganese. Though here occurring together, formed to some extent possibly by similar processes, and superimposed in layers over each other, the iron-ore has almost absolutely repelled the manganese; while no specimen of the psilomelane which I have examined contained a trace of iron. I do not remember ever having examined a mineral which was so absolutely free from the minutest trace of iron.

Cavities in the psilomelane are rarely covered with a velvet-like coating of "*mangan-sammat-ers*."

Low, in his remarks upon this ore, says that it "looks as if it had been once in fusion, and had settled in a number of bubbles." Though its usual occurrence, in fibrous-mammillations after the manner of the hematites, by no means indicates such a mode of deposition, yet I have already had to allude to indications of its having been *intruded* into the veins from without; and there are certain modes of its occurrence now to be described, which go a very long way indeed to show that some portion of it at least had been in a state of liquidity from heat.

To aid in the description of these, diagrammatic figures of actual specimens have been given; these will be referred to by number.

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They group themselves into four varieties.

1. Drops which seem to have been sprinkled over a surface.

2. Drops which seem to have fallen into narrow spaces, and to have moulded themselves to the bounding walls of those spaces.

3. Pendulous masses, which seem to have run down the surfaces of the sustaining substance.

4. Drops which exhibit shrinkage markings, and which, having fallen one upon another, have taken an impression or cast of these shrinkage markings; but which drops are free from all attachments.

In the case of the first three varieties the so-called drops invariably lie upon the surface of the glossy limonite: in the case of the last they do not do so, but upon either the mammilated psilomelane, or upon other drops.

In the first two cases the drops are perfectly spherical, except where in contact with their support, or where by juxta position they impinge upon each other: they vary in size from the smallest sparrow-hail, to bullets which would be about four to the pound.

Their internal structure is obscurely fibrous.

The pendulous masses have also an obscurely fibrous structure; but the drops which came under head No. 4, do not show any structure—being like flint when broken.

Fig. 1, plate X, shows a slab of the rock partially coated with a thin layer of the glossy limonite.

The rock has a very vitrified appearance, and the absence of the iron compound from *part* of its surface, considered along with the reniform margin of the portion of limonite which does sheathe it, is of difficult explanation under any supposition of its having been deposited from water.

Over the smooth and glossy surface of this limonite, and occasionally also over the sandstone itself, there are sprinkled vermiform aggregates of minute spheres of coalescent psilomelane.

The limonite layer is here about the sixteenth of an inch in thickness.

In figure 2 it is about the fourth of an inch, and the surface though glossy is stalactitically fibrous and rough; globules larger than swan-shot are singly or confluently sprinkled over this.

In the specimen figure 3, the glossy limonite (which is sheathing botryoidal psilomelane) has a thickness not much exceeding that of a of varnish, and upon this two large rounded masses lie; and a

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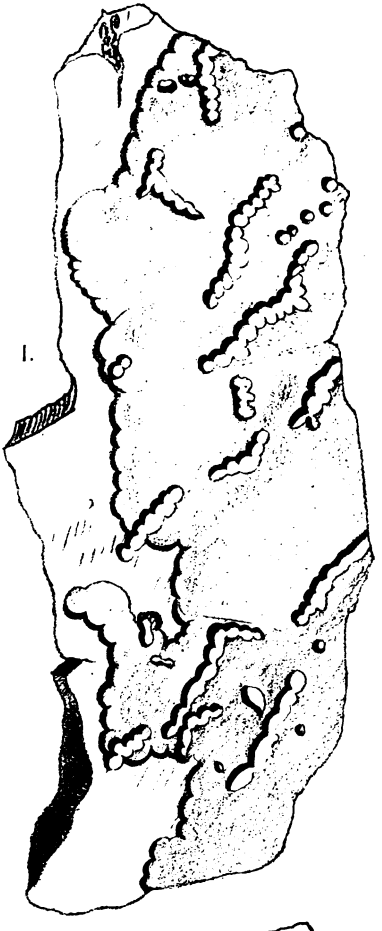

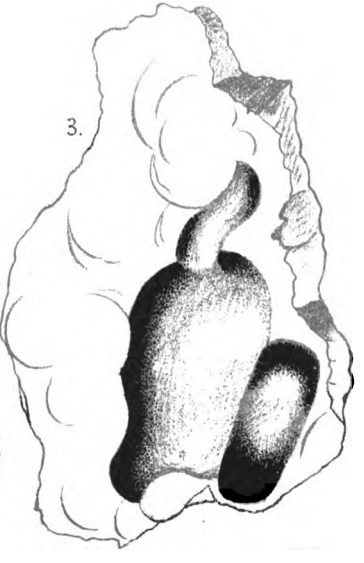

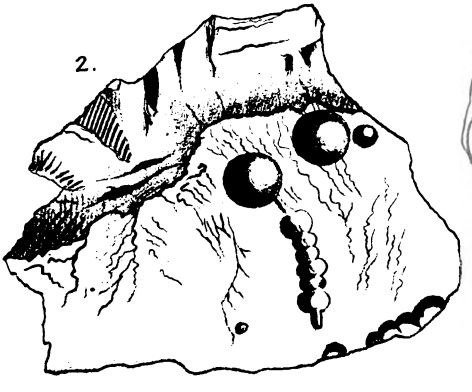

HOY PSILOMELANES.

M. F. H. Del.

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There is here no limonite—drop lies upon drop in immediate contact.

The surface of each drop is highly polished; but it is marked throughout with a number of projecting ridges, which bear the most perfect resemblance to a solidified crust that has been rent and roughened by the contraction of a shrinking and still-liquid centre.

Each drop has taken *the most perfect cast* of that which it has fallen upon (or at least of what it lies upon), both as regards the converging curvitures thereof, and the above-mentioned linear rugosities: and each drop is on *its upper surface* lined and roughened in a perfectly similar way.

If it be a large drop, it envelopes several of those which are smaller and inferior, filling up every interstice between them; and the rugosities upon the upper surface of a large drop are ever larger and more boldly marked than those upon a small one; as might be expected from the contraction of a more ample mass.

While such a structure as this is in every way accordant with igneous liquidity, it appears to be altogether inexplicable upon the theory of watery solution, or of deposition of particles which had been in suspension in a liquid; and the observant Mr. Low was fully justified in saying that it "looks as if it had been once in fusion, and had settled in a number of bubbles."

Figures 4, 5, 6, and 7 illustrate this fourth variety.

4 and 5 represent two confluent "drops;" in 4 they are seen from above, and in 5 in perspective.

Figure 6 shews the shrinkage crust-cracks; 7 is the magnified appearance of one of these, showing an approach to a crystalline structure.

I may here state that I possess from another locality a specimen of perfectly amorphous psilomelane, which fills up all the interstices between a number of "stalactites" of hematite—and these stalactites have a markedly-scorified appearance.

But the question of the liquifiability of the mineral may be, to some extent, determined by actual experiment.

In ascertaining the amount of the water in the two minerals it was found that after the application of the heat—nearly a white heat—obtainable from a three-jet Griffin blast furnace, the crushed powder of the psilomelane had agglutinated throughout; while the portion thereof which was in contact with the sides and bottom of the crucible

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had fused so far as to be firmly adherent thereto, and to have become glistening in lustre.

The fine powder of the wad again—(which differed from that of the psilomelane in its comportment under heat in this, that it became brown at a red heat, while the colour of the psilomelane was unchanged)—was not only fused to the crucible in its lower portions, under the influence of the white heat, but had collected into distinct drops which were more or less rounded.

It has to be kept in view that, under the concentrated energy obtainable in close cavities, and with the larger amount of alkalies which the *unaltered* mineral would contain, the amount and the ease of the liquifacion must have been more complete.

Upon the surface, about a mile south-west of the Lead Geo, pieces of *limonite* are found lying loose. The length of the fibres of these specimens show that the vein from whence they came must have been of considerable thickness. These specimens have naturally been affected by the weather, and sometimes show alternate bands of *yellow ochre* and *red hematite*,—forming strong contrasts.

Among the cliffs of a rocky gorge at the mouth of the stream or cateract called the Burn of the Sail, *Göthite* occurs in veins, in fine specimens. (H) Minute lustrous crystals of it spangle in the druses of a massive granular hematite; and acicularly-fibrous mammilated masses also occur, the fibres being one-and-a-half inches in length.

Its colour is chocolate-brown, sometimes banded with ochrey belts; the fibres are very minute.

Its specific gravity is 4·13. It yielded—

Ferric Oxide	84·395
Ferrous Oxide	·054
Manganous Oxide..	·1
Alumina..	1·295
Lime	1·324
Water	10·863
Silica	2·
	100·031 (H)

The greater part of the Silica was insoluble in acid.

It was quite similar in appearance, and in the colour of its powder to limonite.

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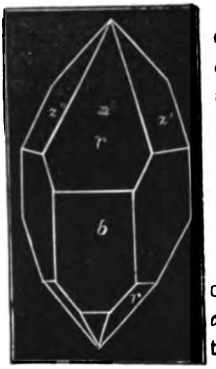
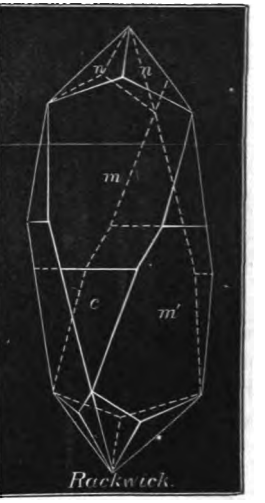


The druses of this Göthite sometimes carry small doubly terminated and symmetrically distorted *rock crystals*, disposed in isolated individuals upon the surface of the göthite fibres; these form specimens of great beauty.

At Rackwick veins of *satin-spar* were found by Clouston: these veins are narrow, and the fibres are too coarse for beauty.

In veins on the north side of this bay, the writer obtained *calcite* in the rare form figured, the crystals are almost an inch in length.



The terminal planes sometimes truncate more deeply so as to cut in upon the faces *c*.

Tremolite is stated to have been found at the Snuke; it probably had been satin-spar which had been mistaken for it.

In the south-west end of the island about half-a-mile north of Turnness, there stands a many-arched stack called the Perforated Rock. The sides of the geos in the neighbourhood yield occasionally reniform *psilomelane*; which indeed occurs in the upper sandstone of the island not unfrequently, though it is generally in thin coatings, and in inferior specimens.

The sandstone here is somewhat more flaggy and micaceous than common, and it carries numerous imbedded fragments of *reddle*, and of a greasy schistose substance which from their round edges and angles would appear to be the worn and altered fragments of an older rock.

At this locality they are usually of a pale brownish-red colour, often passing in part of the fragment to a greenish-yellow. They are very soft, and show occasionally numerous minute scales of mica. They soil the hands.

A specimen which was chosen as being apparently less altered than most, was taken for analysis; it was not one of the most *reddle* or like masses, but rather liker to a shale.

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Its specific gravity was 3·43. It yielded—

Silica	62·555
Alumina	17·252
Ferric Oxide	3·458
Ferrous Oxide	2·21
Manganous Oxide	tr.
Lime	·478
Magnesia	1·619
Potash	4·68
Soda	·598
Water	6·72
	99·565

The large quantity of alumina and alkalies in the above do not point to this being a portion of any of the underlying flags—but do point to its being a portion of a highly micacious rock, either a flaggy gneiss, or most probably a mica schist.

It has been mentioned above, that it is probable that the upper sandstone is cut by dykes,—this is rendered probable by the occurrence of frequent specimens of *chalcedony*, which lie loose upon the surface of the hills,—and also, though sparingly, of *agates*. The latter I have even found upon the shores of Hoy.

The specimens of chalcedony are all of one appearance; they are of a pale blue colour, and invariably show casts of curved dolomite or pearl-spar crystals; and from the freshness and sharpness of these pseudomorphic casts, it would seem as if no great length of time had elapsed since the specimens had been dislodged from their matrix.

The agates are pale blue, banded with white in one arrangement, and occasionally containing imbedded chips? of dense dull-red massive jasper. Still more rarely do they show small *amethystine* crystals.

Small rolled masses of a massive yellow *iron-flint* are also found in similar circumstances.

In the cliff face, about a mile north of the precipice of the Bery Head, a long deep crevice or cave runs landward at right angles to the line of the coast. As this is the strike of the trap dykes, and as it has a width of only about three feet, it has possibly been formed by the washing out or disintegration of one of these. It is now studded with numberless *stalactites* of great purity of colour, and considerable lustre. The floor of the recess is a flat sheet of stalagmite, which sometimes is spread over pools of water, and which, breaking with the

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weight of the body, allows the leg to plunge into a depth which not improbably may be profound.

Near a wide geo at the western end of the Old Head in Walls, the clefts in the rock are filled with small veins of *Albertite* (H); these veins are not above one-third of an inch in width, and it is singular that it is both the vertical and horizontal rents which are filled with the mineral, which sheathes, and, as it were, cements loose fragments of the rock.

Its specific gravity of this Albertite is 1·076. It yielded—

Volatile below 212°	·54	
Gas	65·72	
Carbon	32·83	
Ash (sand)	·91	(H)

Minerals of the Igneous Rocks.

From among the sands of the shore immediately north of the mouth of the Mill burn near the Manse of Hoy, *iserine* (H) may be collected in some little quantity.

The source of this was somewhat of a puzzle, till Geikie found two masses of tufa a short distance westward; from these the black sand may have been brought down by the stream.

These knolls of trap Geikie regards as two of the throats through which the matter of the platform, which may be said to underlie the whole of the north Hill, from the Coolax and the Kame to Rackwick and Rora Head, was ejected.

Of the black sand here found, very little is *iserine*, or indeed magnetic. The iserine yielded—

Titanic Acid	18·4	
Ferric Oxide	54·979	
Ferrous Oxide	14·422	
Alumina..	·6	
Lime	5·6	
Magnesia	·2	
Silica	6·1	
	100·301	(H)

It was in very minute black magnetic grains; these differed considerably in appearance from ordinary granular iserine. When mined with the microscope they were found to consist almost ely of oval grains with rounded outline. They shine like little

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bits of graphite—had few fractures, these were highly lustrous. There was very rarely a doubtful outline of a worn octahedron.

The rocky cliff, immediately above the spot where this iserine is found, forms one of the best flagstone quarries in the island;—and this chiefly on account of the extreme ease with which the flags can be raised. This facility of working is due to the regularly disposed distances of a system of rhomboidal cross-rents.

These resemble, on a large scale, the diamond pavement described near Yesknaby,; the rents of which, it was stated, had been referred to the action of the weather by Dr. Fleming, but which the writer considered were more probably a part of the structure of the rock itself.

The fact that, in the locality at present under notice, this system of rents is found to continue as far back as the rock has been opened, and where it is perfectly sheathed from, and absolutely unaltered by any atmospheric influence, at once negatives the assumption that atmospheric agents have in any way effected it.

Such rents are usually assigned to shrinkage. There are certain facts, however, which are difficult to reconcile with such an assumed cause. These are, first, that the development of the cracks is very much more pronounced and determinate in some situations than they are in others. Second, that it is difficult to understand how the rents should have taken place *in that inequality of distance*, as regards the individual particles, which is the character of a *rhomboidal* structure; and not in the *equality* which the *hexagonal* structure presents,—(as seen in basaltic columns, starch, furnace hearth-stones, and in an inferior degree in sun-cracks)

The third of these facts is that the rents are not at right angles either to the bedding of the rock,—or vertical to the horizon; as we should expect the rents of such a shrinkage to be, as has to be assigned either to *contact* or *radiant* abstraction of *caloric*, or to the removal of water, either by surface drying, or subjacent heat. The system of joints under consideration. at least such as are part of the *physical structure* of the rock., forms an oblique angle with the bedding. This points directly to the operation of mechanical causes, in all likelihood to pressure or *lateral thrust.*

It would be probably going too far to assign the compression, in the case of the Yesknaby pavement, to the closely adjacent dykes between which that pavement lies; because it may reasonably be held that these dykes merely filled up pre-existing giant-rents in the rock.

It may also be brought forward as a difficulty, that the rents occur where there is no curvature, or crumpling of the strata. But it has to

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be maintained that it is just where there are *no* plications of the strata, that compression, perchance obliquely directed upon a substance retained in place by great superincumbent weight, would effect such a result; and there is every probability that the system will be found *to* be best developed where there are numerous faults.

The chief points to be noted as regards the jointing of the Orkney flag-rocks are, that it occurs in an equally well-marked degree where the strata are horizontal, as where they dip;—that the fossils, though frequently rent and having the rents filled with calcite, are not usually much compressed, and seldom distorted; that it cuts thick beds and thin almost alike; and that it occurs in a highly aluminous and frequently bituminous rock,—one in which there is no such approach to uniformity of composition as would warrant the assumption that a segregatory process or the force of crystallization had any share either in producing the jointing or even in influencing its direction.

The tufacious rock of the Burn of Berridale has much the appearance of being *in* the sandstone, as it passes for some distance up the rocky sides of the burn. I found nothing in it but masses of *calcite*.

The "neck," if it be one, at the Burn of Simmary contains *asphalt* and *calcite*.

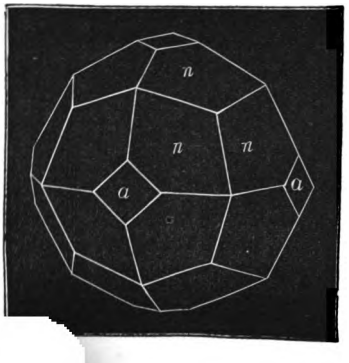
The amygdaloid which occurs at the "Links of Walls" contains innumerable druses.

These at its western extremity are of small size; the "rock-kernels" here consist chiefly of *calcite*, which is coated with light green *celadonite* (H) of a fine colour.

Frequently, however, they are filled with granular *saponite* (H); the specimens are fine; the colour is sap-green.

The druses increase in size towards the east end of the mass, at Sandsgeo.

Here they are frequently coated with a film of minute crystals of *Heulandite*, (H); disposed upon this are crystals of *analcime*—form *Pr*, (H). The centre of the druse is filled up with *pearl-spar* (H), which carries large imbedded lamellar crystals of white *baryte* (H.)



The druses which yield the finest crystals of analcime are found towards the centre of the mass near the sea edge; they are of the form drawn.

They are from half-an-inch up to nearly three inches in size, are translucent and colourless, or with a slight

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pinkish tint, and they show the face P better than the crystals of any other locality in Scotland.

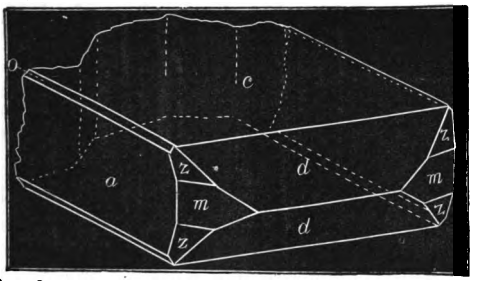
Their specific gravity is 2·244. Their analysis yielded—

Silica	57·624
Alumina	18·724
Ferric Oxide	·193
Ferrous Oxide	·74
Manganous Oxide	tr
Lime	1·888
Magnesia	·459
Potash	1·389
Soda	10·28
Water	8·452
	99·749 (H)

The pearl-spar is occasionally in curved primary crystals. Its specific gravity is 2·78. Its analysis yielded—

Carbonate of Lime	62·4
Carbonate of Magnesia	32·056
Carbonate of Iron	1·74
Carbonate of Manganese	4·276
Insoluble (Quartz)	·16
	100·632 (H)

Chalcedony in thin coatings rarely covers pearl-spar.



The baryte is rarely in small crystals of the form *c a o d m z*, as drawn.

Imbedded in the pearl-spar I obtained a single specimen of *Babel-quartz*. It was of the fine tint of colour which pertains to the Ben Lawers and Craig Cailleach quartz,—a mixture of brown and amethystine.

Rarely there occur in this amygdaloid druses filled with a mixture of pearl-spar and small foliæ of *rubin-glimmer*; layers of the latter being deposited in bands which accord with the shape of the druse.

The above paragenesis of analcime, pearl-spar, and baryte, I have found to occur in other localities.

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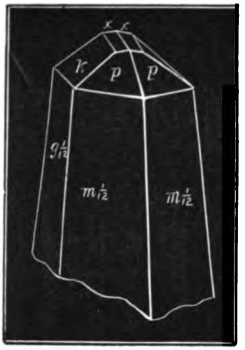
ISLAND OF FARAY.



On the west shore of this island some attempts were made to work *galena*. It occurs rarely in cubo-octohedral crystals.

Dr. Fleming found at this spot a vein of *satin spar* about two inches in width; it is of somewhat a grey colour, but is fairly firm in the fibre, and hard.

Arragonite rarely occurred in crystals; the form in the margin is that of the *Unst* crystals.

STACK AND SKERRY.

Though these two rocks are somewhat nearer to Hoy than to the Sutherland coast, geologically they belong to the latter county; for they are formed of a syenite which contains *sphene*, and which is identical in appearance with the syenite of Ben Loyal.

The two would thus appear to be the summits of two hills, much resembling Ben Loyal and Ben Stomino;—a craggy peak, and a flattish dome.

Recent depression of the land. This is considered by many as having, without doubt, taken place. The conclusion is arrived at from the two circumstances of the sea now standing where once there was land,—and from trunks of trees, hazel nuts, and leaves having been dug from beneath sand, at low water-mark, or from their having been thrown up by the waves.

The two may be but one piece of evidence; and that may be shown to be capable of explanation, without calling for any even local movement of the earth's crust,—although such movement is a perfectly recognised, as it has been indeed an oft-repeated fact.

It is probably the case that the fact that the great Bay of Otterswick, in Sanday, was formerly land, is regarded by many as having been more of the nature of an *invasion of the sea*; and it may be that the very fact of its having been said to have occurred in *one night*, may lead to a proper understanding of what had taken place.

Many trunks of trees are said to have been found beneath the sand all round this bay. The locality in which the writer had the best

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opportunities of observing the circumstances and surroundings, was a small bay upon the coast of Rousay, nearly opposite to the little island of Enhallow.

From beneath the sand of this semi-circular bay, tricklings of a logwood-red water may, generally during any unusually low tide, be observed to issue; and the sorely decayed stems of brown-red trees may be seen to project. Upon making the circuit of the bay, it will be observed that these stems slope everywhere, with a very decided dip, inwards to the centre of the bay, or rather to the centre of a circle, of which the shores of the bay would form about a fourth part.

The trees had evidently grown where they fell;—had grown around the circumference of a fresh-water lake,—had fallen upon its banks, or into its waters, to be buried beneath its silts and sands.

Many lakes may at the present time be pointed to in Orkney scarce above the limit of the saline waters;—in the largest of them all indeed, through a very unusual and altogether lunatic arrangement,—fresh and salt maintain a rhythmical possession, for one-half of each day.

There is present evidence, in more than one part of the semi-submerged islands, that through the constant shore nibblings of the sea, the last barrier between it and these littoral lakes, had been one of those boulder-breaches of stones, locally termed "ayres."

Through the open crevices of these ayres the soaking waters commenced their sap; carrying out grain by grain during every tide, the ooze and muddy silts which underlay the peaty and vegetal bottoms of the fresh-water pools;—lowering, through long continued and incessant action, the lake-floors, till the inner prop to the boulder-breach was gone, and, in some time of heavier breaker assault, itself succumbed.

There thus came to be a "little sea" within the land, imperfectly cinctured by a projecting tongue of stones. Rapidly now would the daily sweep and drain of waters suck out its pulpy bed, till the sides "caved in"; its already buried trees would be buried afresh by layer after layer of the sea-shore sand, up to the time when the biting tooth of the ocean made a bay of what had been a lagoon; and, with purpose constant and yet inconstant as its own ebb and flow, to-day would swaddle up what to-morrow it would again lay bare.

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XXII—*On Serpentinous Minerals from the Saas Thal and from Scotland.*

By Captain Marshall-Hall and Professor Heddle.

IN a letter to Dr. Heddle, Capt. Marshall Hall writes—"On the next page I give you, in complement of my last letter, the analysis of a serpentine from the Saas Thal. For the specimen I am indebted to M. Henri de Saussure. It will be interesting to compare it on the spot, and study it in its relations to the accompanying rocks and minerals.

Whether the stone is fairly serpentine with so much iron is perhaps to be questioned; I send the analysis as that of a "reputed" serpentine, and I send it to *you* as you have been doing serpentines, ... as it is possible that additional data may be of use to you.

The specimen was a rounded flattish pebble, compactly schistose.

Sp. gravity 2·56;—tough to break.

SiO_2	40·56
Al_2O_3	1·40
FeO	10·83
CaO	0·16
MgO	35·20
Loss on ignition (H_2O?)	11·80
	99 95

This analysis was made under the difficulties of no laboratory, no gas, and imperfect appliances generally.

In order to get at the lime, of which I found traces, I took too large a weight of substance, hence the pyrophosphate of magnesia *may* not be quite washed, the precipitate being too bulky. But as this does not appear to me to tend to misguide as to the nature of the rock, I shall not do the analysis overagain. The colour of my solutions indicated *chromium*, but nitrate of silver and acetate of lead did not afford me confirmative evidence. I valuemy domestic peace too highly to take a great lot and examine the H_2S and the NH_4HS precipitates on a large scale. I am rather a nuisance to my family as it is!

With the exception of this, I made a pretty complete qualitative analysis, and *failed* to find Cl, BO_3, SO_3, PHO_5, HFl or CO_2. I did find

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SiO_2, FeO, Al_2O_3, CaO and Mg,O, and the emerald and brownish colourations which make me suspect chromium. Also a brownish violet bead seemed to indicate mixed nickel and cobalt, in the NH_4HS group. C_yKS gave so feeble a re-action that any little quantity of Fe_2O_3 might have become oxidised during fusion, solution, and evaporation."*

This is an interesting illustration of the transmutation of what had probably been *enstatite*, into serpentine. It seems to stand nearly intermediate in the amount of its change between the two following Scotch specimens.

On the north-west slope of the Green Hill of Strathedon in Aberdeenshire, there are to be found specimens very similar to *bronzite*. These may be traced, with a gradual disappearance of their brown colour and their metallic lustre, to a bed of rock which upon a first inspection appears to consist of an *unaltered hornblende*. Closer inspection, however, discloses a certain amount of greasy lustre, while the knife shows that there is a deficiency of hardness. The mineral breaks into broad cleavable masses, of a dark-green colour, and a structure which is broad-foliated, but is also obscurely-fibrous.

The specific gravity is 3·01.

Analysis :—

Silica	50·921
Alumina	1·893
Ferric Oxide	9·427
Ferrous Oxide	2·085
Manganous Oxide	·307
Lime	8·645
Magnesia	21·582
Potash	·343
Soda	·433
Water	4·536
	100·172 (H.)

In this mineral, in this its less-altered condition, the *apparent* change is so slight that the eye alone could not have detected it; and it would not have been selected for analysis, had not the bronzy and more-altered specimens rendered it desirable to ascertain what were the *first steps* of the alteration.

The other specimens were found much further down the slopes of the same side of the hill. These much more resembled an alteration product of sahlite or enstatite. They occurred loose, and had palpably suffered much

* The serpentine was difficult to fuse with alkaline carbonates. M.H.

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change. They were of a dull olive-green colour passing to fawn: they had a laminated or flatly-cleavable structure, with cleavages having angles near to those of augite. They were devoid of lustre, slightly porous, but had plates of talc of extreme tenuity lying between the cleavage planes. Their specific gravity was 2·158; they were brittle and easily friable.

Analysis:—

Silica	37·412
Ferric Oxide	12·925
Ferrous Oxide..	·056
Manganous Oxide	·24
Lime	·179
Magnesia	34·764
Water	13·594
	99·787 (H.)

With traces of alkalies, and 4·545 per cent. of hygroscopic water.

Both of the above contained traces of carbonic acid. Of the first it has to be said that so extensive an amount of peroxidation of the iron could not have been supposed to be compatible with the retention of a bright-green colour and a brilliant lustre; of the second, that the substance bore no resemblance to the *mass* of serpentine, but did much resemble the *brown crust* which so frequently envelopes serpentine rocks.

Compared with these specimens, it has to be remarked of that examined by Capt. Marshall-Hall, that the point most to be noted is the fact of the iron remaining in the state of protoxide, while so much water has been introduced, and silica abstracted;—the small quantity of lime, and the absence of carbonic acid have also to be noted. Its *compactly-schistose* character goes some way in indicating hornblende and not enstatite as the original mineral.

The accumulation of analyses of such substances is the first step in arriving at a knowledge as to the nature of the formation of serpentine.

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XXIII.—*On the occurrence of Celestine in New Red Marl, near Sidmouth.*

By Spencer George Perceval.

Communicated by F. W. Rudler, F.G.S.

WHILST staying at Sidmouth, in 1877, I discovered the occurrence of Celestine, Sulphate of Strontian, in cavities of Red Marl lined with crystals of Calcite, occurring in masses which had fallen from the cliff on to the shore, under the summit of Peak Hill. It appears in the form of crystals, occasionally one inch in length, which occur singly or in groups, presenting a tabular, prismato-tabular, or prismatic form,—in the latter case resembling the Barytes Crystals of Alston Moor,—and are either simple, or form compound aggregations of considerable size. In colour they are blue, wine-yellow, or of an olive-yellow hue, and as regards form, brilliancy, and transparency, surpass in beauty any examples of this mineral that I have hitherto seen. A series of the choicest specimens collected by me are exhibited in the Museum of Practical Geology, Jermyn Street.

I am informed by Mr. P. O. Hutchinson of Sidmouth, that a small specimen of the mineral was found about 50 years ago, in Salcombe Hill, east of the town, but its occurrence in Peak Hill, west of Sidmouth, appears to have escaped notice.*

* In Greg and Lettsom's Manual of Mineralogy, Celestine is stated as occurring at Sidmouth "on gypsum" and "in flints." Mr. Hutchinson is unacquainted with these modes of its occurrence at Sidmouth, but if the gypsum association is correct, the locality where the mineral is thus found would probably be *east* of Sidmouth, in which direction gypsum does occur. In the British Museum and in that in Jermyn Street, are examples of Celestine occurring on flint from Montmartre, near Paris, but none from Sidmouth.

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Reviews and Notices.

On the Phosphates of Copper (A. SCHRAUF, *Zeitsch. f. Kryst. u. Min. P. Groth. IV*, 1.)

THIS paper consists of observations on the minerals Lunnite, Libethenite, Thrombolite, and Veszelyite.

The Lunnite group.—Hermann and after him Rammelsberg have divided this group into three leading types:—

Dihydrite	$Cu_5 P_2 H_4 O_{12}$
Ehlite	$Cu_5 P_2 H_6 O_{13}$
Phosphorochalcite	$Cu_6 P_2 H_6 O_{14}$

All analyses that have been made up to the present fall within the limits thus assigned, but it is nevertheless difficult to discover from these same analyses which variety predominates in any one locality. Besides this, phosphoric acid or water have in many cases been determined by difference, so that the total error of the analysis is accumulated in the determination of one component; a comparison of the various analyses shews great differences in the amounts found, CuO varying between 66·55% and 71·16%, P_2O_5 between 19·63% and 25·30%, and H_2O between 5·97% and 9·06%.

The morphological observations of Haidinger and of Levy shew similar discrepancies; most modern authors, with the exception of Dufrenoy have, however, ignored those of the latter, in spite of their accuracy.

To facilitate the study of these minerals it is best to unite into one group all those that have similar characteristics (monosymmetrical, $\infty P = 140°$; Sp. gr.=4·2; Cu=67—71%, H_2O=6—9%) as has been done by Dana; it is, however, preferable to restrict his name of "pseudomalachite" to the amorphous varieties, and to substitute Lunnite as the name of the entire group, which embraces amorphous, crystalline, and crystallised varieties, both aggregated and isolated crystals, which two latter are better considered separately.

The author has examined specimens from Rheinbreitbach, Ehl, Libethen, Nischne-Tagilsk, and Kreuszberg (Bohemia), but his observations also agree well with those of Breithaupt and Hermann the crystallised varieties from Nischne-Tagilsk and Ullersreuth.

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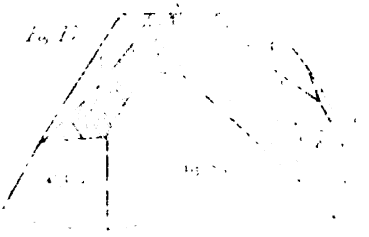

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Lunnite is apparently monosymmetrical, but the right and left sides of the crystals are not quite geometrically equal. The system of parameters is therefore: Triclinic $\alpha=89°\ 29'.5, \beta=91°\ 0'.5, \gamma=90°\ 39'.5$, $a:b:c=2{\cdot}8252:1:1{\cdot}53395$.

The larger crystals from Rheinbreitbach are polysynthetic, consisting of lamellæ lying parallel to 100. Twin crystals occur formed in accordance with the three following laws:—

(1) Twinplane 100. (2) Twinplane 010. (3) Axis of revolution the axis Y; these are the most frequent laws of twinning in the triclinic system.

Isolated Crystals.—The following is one of the numerous sets of measurements given by the author, the crystal (derived from a specimen from Ehl) being similar to the one represented in the figure (plate XIII, fig. II) except that the left side is not in its normal position, but is twinned, so that $\bar{m}_y$, $\bar{\omega}_y$, occur instead of M, Ω.

	Observed.	Calculated.		Observed.	Calculated.
a m ..	69° 48′	69° 55′	a $\bar{m}_y$ ..	69° 55′	69° 55′
a $\bar{\omega}_y$ ..	57° 29′	57° 29′	$\bar{m}_y$ $\bar{\omega}_y$ ..	47° 55′	47° 55′
m $\bar{\omega}_y$	106° 59′	106° 47′	a W ..	20° 21′	20° 19′
a D ..	74° 56′	74° 36′	a d ..	75° circa	73° 31′
D d ..	96° 45′	96° 25′	D $\bar{\omega}_y$ ..	83° 57′	83° 34′
d m ..	37° 10′	37° 28′	D $\bar{m}_y$ ..	38° 40′	38° 17′
angle $\bar{\omega}$ a m	127° 8′	126° 49′	angle $\bar{\omega}$ a d	92° 25′	92° 9′
angle $\bar{\omega}$ a $\bar{m}$	52° 11′	52° 11′	angle $\bar{m}$ a m	179° 19′	179° 0′

This last zone angle (179° 19′) is decisive evidence against the assumption of the monosymmetrical system, which would require that $\bar{m}$ a m should equal 180°. As perfectly similar results have been obtained with crystals from Rheinbreitbach by the author, and, according to the descriptions of Breithaupt and Hermann, also with specimens from Nischne-Tagilsk and Ullersreuth, it is impossible, from its morphological characters, to divide this class into two species.

Aggregated Crystals.—Many of the hemispherical masses of Lunnite from Rheinbreitbach consist of radiating, imperfectly developed crystals, whose free ends shew sharp bright planes on the drusy surface of the hemisphere. The author gives numerous goniometric measurements, from which he concludes that these aggregated crystals only differ from the isolated ones in not shewing the protoprism $\infty P=141°$—a difference by no means sufficient to admit of any division into

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separate species, more especially as both agree absolutely in optical characters.

Chemical investigations.—The author gives a large number of analyses both by himself and by other authorities, and finally arrives at the following conclusions:—(1) The amorphous masses, reniform, in concentric layers, which so exactly resemble malachite as to entitle them to the name "pseudomalachite," consist of binary or ternary mixtures in various proportions of Phosphorochalcite ($Cu_6 P_2 H_6 O_{14}$), Ehlite ($Cu_5 P_2 H_6 O_{13}$), and Dihydrite ($Cu_5 P_2 H_4 O_{12}$). They lose perceptibly in weight on heating to 200° C, and have a sp. gr. of 4·2. (2.) The greyish-green fibrous radiating masses from Ehl, with H=2 and sp gr.=4·1, consist of superficially decomposed Dihydrite, and contain silicate of copper; the name Ehlite may be given to this variety. (3) As the proportions of water and copper increase, the crystallising power of phosphate of copper appears to decrease. (4) The crystallised varieties of Lunnite contain the smallest proportion of water, have the highest sp. gr. (=4·4) and consist mainly of Dihydrite, shewing no loss of weight on heating to 210° C. The name Dihydrite should be restricted to this variety.

Libethenite.—The hitherto published measurements of the angles of this mineral by Rose, Mohs, Phillips, etc., shew discrepancies to the amount of about 3°, an amount that cannot be due to errors of observation, and must not be ignored; two explanations alone are possible: (1) The so-called Libethenites from different localities may have different compositions. (2) The morphological structure of Libethenite may be more complicated than is generally supposed. The author now proceeds to shew that this second hypothesis is the correct one; from numerous measurements cited in the original paper, he deduces the following system of parameters:

$$a : b : c = 1{\cdot}4255 : 1 : 1{\cdot}34625. \quad \beta = 90° 56',$$

thus referring Libethenite to the monoclinic system, whilst the peculiar position of the planes is produced by the revolution of m or M into a twin position on the planes 100 or 001—the commonest laws in the monoclinic system.

It thus appears that the earlier observations were correct, but not sufficiently numerous, and their discrepancies can be well explained by the pseudo-symmetry of the mineral. The outlines of a crystal, which may even seem to be homogeneous, are not always produced by particles (planes) in a normal position, but molecules (planes) in twinned positions may take part in the formation of the superficial layer, and lie in it smoothly without producing an entirely new crystal. Thus, positive

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planes take the place of negative ones, or *vice versa*, and produce pseudo-symmetry. These multiple twins differ from ordinary polysynthetic twins, in the respect that, in the former, the twinned molecules have not been able to develope themselves fully, but only form portions of the planes; the laws, according to which twinning takes place are, however, the same in both cases, but the number of molecules involved, and the mode in which they are put together, are different. In order to distinguish this variety of twinning produced by the molecular rotations of portions of planes, the author calls this phenomenon "Polydymy."

Thrombolite.—Breithaupt and Plattner described this mineral in 1838 as a Phosphate of Copper. The author finds, however, that it does not contain any phosphoric acid, but has the following composition:

Loss on ignition	(H_2O)	16·56	[Plattner 16·8]	
	Cu O	39·44	[Plattner 39·2]	
	Fe_2O_3	1·05		
	Sb_2O_5	6·65		
	Sb_2O_3	32·52		42·95
Loss ..	(Sb_2O_3?)	3·78		
		100·00		

This composition corresponds tolerably well with the formula $10\,CuO + 3\,Sb_2O_3 + 19\,H_2O$. The proof of the presence of antimony in thrombolite throws much light upon the remarks of Peters on the paragenesis of this mineral; he states that tetrahedrite embedded in the ore-bearing limestone of Resbanya was changed into amorphous thrombolite. Whilst the formation from tetrahedrite of a phosphate could only have been the consequence of a series of secondary re-actions, simple oxidation would suffice to convert it into Thrombolite, the sulphuric acid thus generated combining with the lime of the matrix.

Veszelyite—a species first established by the author in 1874. The following is a more complete account of the mineral:—Veszelyite forms thin incrustations upon garnet-rock, and upon the brown hæmatite which is a decomposition product of the latter; these incrustations consist of a granular aggregate of imperfectly developed crystals; isolated crystals also occur.

System triclinic; $a : b : c = 0{\cdot}7101 : 1 : 0{\cdot}9134$; $\alpha = 89°31'$, $\beta = 103°50'$, $\gamma = 89°\,34'$. The prism (110) predominates combined with the doma

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(011). Color and streak bluish-green. Hardness 3·5—4 Sp. Gr. 3·531. The following is the analysis :—

Cu O	..	37·34
Zn O	..	25·20
$P_2 O_5$	..	9·01
$As_2 O_5$	..	10·41
$H_2 O$	..	17·05
		99·01

Veszelyite therefore consists of

$$\left\{\begin{array}{r} Zn_3 As_2 O_8 + 3\,Zn(HO)_2 + 3\,H_2 O \\ Cu_3 P_2 O_8 + 3\,Cu(HO)_2 + 3\,H_2 O \\ 3\,Cu(HO)_2 + 3\,H_2 O \end{array}\right\}$$

The mineral occurs at Morawicza in the Banat; it was found by Mr. Veszelyi, after whom it has been named.

H. L.

HERRENGRUNDITE (A BREZINA, *Zeit. fur. Kryst. und Min. III*, 4, *p.* 359.) This is a new basic copper sulphate from Herrengrund in Hungary, occurring in "Grauwacke slate" with malachite and calcite. Crystals as in figs. 7 to 10, plate XIII. H=2·5; composition according to Dr. Berwerth.

SO_3	..	24·62
CuO	..	54·16
CaO	..	2·05
H_2O	..	19·61
		100·44

J. H. C.

CALCITE (J. R. MC D'IRBY, *Zeit. f. Kryst. und Min. III*, 5 *and* 6, *p.* 612.) Some remarkable calcite crystals described by J. R. Mc D'Irby of Lynchburg, Virginia, in his work "on the Crystallography of Calcite (*Inaug. diss. d. Gottingen Univ., Bonn*, 1878) are represented in plate XIII, figs. 11 to 13.

J. H. C.

PSEUDOBROOKITE (A KOCH, *Zeit. f. Kryst. und Min., III*, 3, *p.* 306.)—The figure of this mineral given by Koch is reproduced in Pl. XIII, fig. 2. The composition, &c., was given in the *Mineralogical Magazine*, vol. II, p. 248.

J. H. C.

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EGGONITE (A. SCHRAUF, *Zeitschrift f. Kryst. und Min. III*, 4, 352, *fig.* 1, *pl. XIII*) was found upon single crystals of silicate of zinc from Altenberg near Aix-la-Chapelle, formed in cavities, coarsely granular, from ferriferous clay mixed with calamine. The name Eggonite (ἔγγονος grandchild) indicates that it was observed as third in degree in the series of the natural zinc-cadmium combinations.

Triclinic; a : b : c=1·3360 : 1 : 07989. The axis angle β=90° 50′: Planes observed (010) (02$\bar{3}$) (023) (32$\bar{0}$) (320) (100). Twin formation (010), changes the asymmetry into an apparent monosymmetry. H=4-5; cleavage unknown. Powder shows leaf-like particles. Color light greyish-brown; streak white; imperfect adamantine lustre; translucent to transparent. Before the blowpipe infusible, becoming gray and opaque. With soda carbonate upon charcoal melts to an enamel-like glass, and gives the cadmium incrustation. Zinc incrustation not observed. In HCl and HNO_3, insoluble; or very imperfectly so; with microcosmic salt, gives a *Siliceous* skeleton. Eggonite is therefore essentially a silicate containing cadmium: Morphologically and paragenetically Eggonite stands next to Hopeite.

T. A.

ON SOME METAMORPHIC ROCKS OF THE HIGH ALPS (By DR FR. ROLLE, *Imp. Geolog. Institute of Vienna, Report of Meeting, May* 31, 1879.)—The crystalline and semi-crystalline rocks of the High Alps of the Grisons, Tessin, and Chiavenna are all sedimentary deposits, more or less metamorphosed. The Casanna schists, consisting of quartz and mica, and lying between garnet-bearing mica-schist and "Verrucano," represent the Carboniferous group. The green schists ("Chlorogrisonite") above the "Verrucano" and the Triassic limestones and dolomites, are variable aggregates of plagioclase, epidote, actinolite, magnetite, specular-iron, and cyanite. They are divisible into *Valrheinite* (plagioclase, epidote, chlorite), *Cucalite* (plagioclase, epidote, and a small proportion of actinolite), *Paradiorite* (plagioclase, actinolite, and some epidote), and *Hypholite* (actinolite in prevalence, plagioclase, and magnetite.) The essential components of the grey schists are quartz, mica, and an opaque substance. They probably consist of detrital gneiss and mica-schist, subsequently metamorphosed. The origin of the green schists may have been connected with the eruption of pyroxenic volcanic ash.

COUNT M.

ON SOME SPECIMENS OF NEPHRITE (By DR. FR. BERWERTH, *Imper. Acad. Sciences, Vienna, Report of Meeting, July* 17, 1879.)—Crystalline

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portions of a block of New Zealand Nephrite, weighing 123·32 kilogrammes, proved to be identical with *actinolite* both in crystallographic and chemical constitution. The crystals are separately imbedded in compact Nephrite. The largest of them measure five millimeters in length. Under the microscope they offer the same characters as the crystals of actinolite embedded in the talcose and chloritic schists of the Alps. The chemical composition is the same as that of the actinolite of Arendal, analysed by Rammelsberg. It answers to the formula—Si_{20} Fe_2 Ca_5 Mg_{11} H_6 O_{62}.

The compact portion of the block seemed to be a compound of compressed and intricate fibres, including some few scattered crystals of Actinolite. The chemical formula for the compact mass is Si_{10} Fe_2 Ca_5 Mg_{11} H_6 O_{62}. This is the same as that of several fragments of nephrite found in lacustrine habitations. A variety of nephrite, called "Kawakawa" by the New Zealand natives, has been analysed, and its formula ascertained to be Si_{20} Fe Ca_5 Mg_{12} H_6 O_{62}.

COUNT M.

THE MELAPHYRE OF HALLSTATT, UPPER AUSTRIA (By F. VON HAUER, *Imper. Geolog. Institute, Vienna, Report of Meeting, July* 31, 1879.)—In the winter of 1878 melaphyre was met with in the Salt-mines of Hallstatt. It is dark-green, compact, of amygdaloid structure, and in a state of advanced decomposition. Its cavities and fissures are filled with pellucid rock-salt and some gypsum. Microscopic examination of thin slices shows it to be composed of small crystals of plagioclase, a chloritic mineral, and a small proportion of magnetite, interspersed with larger crystals of plagioclase, decomposed pyroxene, and a substance showing many grey points. In some cases, yellowish-brown, partially decomposed pyroxene is discernible; and the structure of some decomposed portions proves that olivine was present previous to the decomposition. The whole is impregnated with rock-salt and gypsum. Silica occurs in cavities, either amorphous, or as quartz. The results of chemical analysis are:—Substances (1) soluble in water (chloride of sodium and gypsum) 10·90 per cent; (2) soluble in chlorhydric acid, after treatment with water (sesquioxide of iron, alumina, lime, and magnesia,) 35·55 *p.c.*; (3) insoluble in chlorhydric acid (silica, lime, alumina, and magnesia, 47·10 *p.c.*; water and the alkalies (calculated by the difference) 9·45 *p.c.* A direct determination of the silica gave 44·25 p.c., hygrometric water, 1·26 *p.c.*, loss by ignition, 7·45 *p.c.* Another specimen gave 2·54 *p.c.* of chloride of sodium and traces of gypsum.

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The melaphyre appears to constitute a *Massif* amidst the saliferous rock, striking S.E.—N.W.: near its south-eastern termination it takes the form of a breccia, with fragments enclosed in the salt-rock. Westward it is separated from the overlaying, feebly saliferous rock, by a seam of gypsum. These melaphyres may be of Triassic age.

COUNT M.

On the Diffusion of Cerium, Lanthanum, and Didymium.—(A communication from Prof. A. Cossa, of Turin.—*Bull. de la Soc. Min. de France*, 4, 1879.) In 1846, Wöhler observed that apatites from Arendal, in Norway, contained 2 to 3 per cent. of a crystallised phosphate of cerium, irregularly distributed in a state of mechanical mixture, and which he called Cryptolite. It may be separated from the apatite by dilute nitric acid, in which it is insoluble. In 1851, Weber found the oxides of cerium and yttrium in apatite from Snarum. In 1872, Church found phosphate of cerium in apatite from Jumilla. The author has analysed fourteen specimens from the most diverse localities, and finds that they all contain phosphates of cerium, lanthanum, and didymium, united molecularly to phosphate of lime, and that cryptolite therefore does not really exist. His observations were made with a small spectroscope, and verified in the case of the apatites from Snarum, Bamle, and Canada, by chemical analysis, the details of which are given. The three apatites just mentioned furnished solutions which exhibited clearly the system of brilliant striæ characteristic of the electric spectrum of lanthanum.

The presence of cerium, didymium, and lanthanum has been found in many apatites which do not exhibit an absorption spectrum, and also in three specimens of limestone, viz.: saccharoid marble from Carrara, a shelly limestone from the province of Avellino, and lastly in a stalactitic deposit in an earthenware pipe leading from a Roman aqueduct near Cividale, in Frioul. These last experiments were made with the greatest precautions on about two kilos. of limestone each time; each kilo. gave about 2 cgrms. of oxalates of cerium, lanthanum, and didymium.

Experiments were made on the Scheelite of Traversella, which contains about 0·22 p.c. of oxides of cerium, lanthanum, and didymium; and on that from Meymac (department of Corrèze), in which the proportion is much less.

The author then describes how he has artificially produced didymiferous Scheelite and crystallised tungstate of didymium. For this purpose amorphous tungstate of lime, obtained by double decomposition, was melted with chloride of sodium, and a small quantity of tungstate of didymium was added, when crystals of Scheelite were obtained, perfectly transparent and spectroscopically identical with crystals from Traversella.

R.C.B.

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On the Hemihedral Forms of Alums (M. G. UZIELLI, *ibid.*)—With reference to the previous observations of M. Lecoq de Boisbaudran, the author remarks that, in crystals of chrome alum, striæ occur on the planes perpendicular to the face $a' = (111)$ which lies on the bottom of the vessel, and also on faces symmetrically placed with regard to that face.

If an octahedron rest on one of its faces a', the six oblique faces are inclined to that face; the striæ then appear only on the three faces visible in the perpendicular projection of the crystal on the plane of the face a'. As these three faces belong to a tetrahedron derived from the cube, and the striæ are normals to the edges of the face, *i.e.* they are in planes perpendicular to the faces of the rhomboidal dodecahedron; the fact can be explained by the ordinary laws of hemimorphism.

At the conclusion of this paper, some remarks are made by M. Lecoq de Boisbaudran, in which he states that he found no striæ in the crystals prepared by himself, but there were four rugose, dotted faces, and four smooth ones. M. Uzielli's striæ have no connection with the internal structure, and they have always a fixed orientation with respect to the lower face of the crystal; so that they are simply furrows cut by currents produced in the liquid by change of density. They follow the direction of gravity, and similar furrows occur also in the erosion of other substances.

R. C. B.

On the Optical Properties of Isomorphous Mixtures (M. G. WYROUBOFF, *ibid.*)—The researches of De Senarmont and Des Cloiseaux have shown that optical isomorphism is quite different from geometrical. The phenomena of isomorphism may be considered under three heads,—geometrical, chemical, and optical,—independent in so far that an identity in each can exist without entailing an identity in the others. Thus regarded, isomorphism ceases to be a general law which must be continually supported with new hypotheses, and becomes a series of special laws.

The author divides those substances which can crystallise together, and produce isomorphous compounds, into three groups:—those which are chemically, geometrically, and optically identical; next those agreeing only in composition and form, and lastly those which are similar in composition, but differ in form and optical deportment. Red light was always employed by the author, in order to eliminate dispersion, and in cases where there was not sufficient transparency, the measurements were made in oil.

Group 1.—Optical properties are numerous and complex: they include index of refraction (and consequently the angle of the axes in biaxial

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bodies), the properties of double refraction and dispersion, and the orientation of the plane of the axes. All these points assist in the determination of species, but, for the present purpose, the first-named has a constant value. The index of refraction and the angle of the axis vary under conditions which are far from being understood—not that they are to be excluded from the conception of optical isomorphism, but they are secondary, the position of the plane of the axes remaining characteristic, and it is to this that attention will be confined. Two substances are selected because they form perfect crystals, and belong to the same series as the very curious double sulphate of soda and potash. The optical axes of the sulphate and the chromate of potash have the same orientation, parallel to $h'=(010)$: there is a difference only in the position of the acute bisector, and in the sign of the double refraction, which in the case of the sulphate is positive, and perpendicular to $p=(001)$, while in the chromate it is negative and perpendicular to $g'=(100)$.

When the two salts crystallise together, 6 p.c. of chromate suffices to alter the optic axes of the sulphate, the obtuse axes of which gradually approach, and when the proportion of chromate reaches 44 p.c., the axes of the pure chromate are obtained. At this point the salt is geometrically still the sulphate; the crystals are mostly combinations of m, e', g', with this last face much developed. With a slight addition, however, the form changes; the face g' disappears, and the faces $e'=(101)$ prevail; the crystals also lose their transparency, and do not regain it till the quantity of sulphate has decreased to 3, or even 2 per cent.

Group 2.—In this case a mixture of the sulphates of potash and ammonia is employed, their form being exactly the same, but the optic axes are differently oriented—parallel to $h'=(010)$, with the positive acute bisector parallel to $p=(001)$, in the former; parallel to $g'=(100)$, with the positive acute bisector perpendicular to h', in the latter. 2 p.c. of sulphate of ammonia suffices to bring the obtuse axes of the sulphate of potash nearer, this effect proceeding regularly at the rate of 4° 40′ for each per cent. of ammonic sulphate, or by 1° 10′ for each thousandth of ammonia. On reaching 18 p. c. ($=7$ p.c. of NH_4), they cross, and give an almost uniaxal salt. Their plane then becomes parallel to p, and they diverge more and more, proceeding this time more rapidly, at the rate of 6° 30′ for each percentage of sulphate of ammonia. They thus come to form a right angle with about 30 p.c. of sulphate, presenting probably an obtuse bisector, the acute bisector being perpendicular to h'. To attain the optical properties of pure sulphate of ammonia, the axes must again cross, and then diverge in a plane parallel to g'. But the last phases of the transformation are difficult to follow, for when the quantity of sul-

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phate of ammonia exceeds 30 p.c., the crystals become small and indistinct, and form complex macles.

Group 3.—To this group belong the mixtures of the sulphates of potash and soda, and of the chromates of the same bases. The two sulphates, chemically isomorphous, are not geometrically so, since the sulphate of potash has (for the prism) an angle of 120° 24′, and that of soda an angle of 129° 20′; the orientation of the optical axes is also different. The same remark applies to the two chromates, except as regards the optical deportment, for that of the chromate of soda is not known. Nothwithstanding this dissimilarity, the two sulphates or the chromates unite in indefinite proportions. It might be said—in accordance with a phenomenon of dimorphism—that sulphate of soda has two forms, one known, the other unknown, and resembling sulphate of potash, as happens with the nitrates of potash and soda. But this hypothesis is based on analogy, not on facts directly observed, dimorphism not having been hitherto observed in sulphate of soda. Moreover a series of facts seem to contradict such a view, for in a mixture of two bodies, of which one is dimorphous, the one form being stable and the other unstable, it is found that one of these forms, generally the more stable, has a great morphogenic power. This happens with the sulphates of iron and of zinc, 20 per cent. of the former being sufficient to give the clinorhombic form to the mixture. The sulphates of iron and of zinc, the sulphates of iron and of magnesia, the nitrates of potash and of soda, are all thus identical. Sulphate of iron which has 70 per cent. of sulphate of zinc is optically, pure sulphate of iron, not only by the position of the plane of its axes, but also by their angle, while sulphate of zinc with 10 per cent. of sulphate of iron is optically pure sulphate of zinc.

Such is not the case with the two sulphates of potash and soda. Intermediate forms exist, but, since rhombohedral crystals have very nearly the same angles as rhombic crystals, there is very little geometrical difference. The double sulphate is however very difficult to study optically; well formed crystals are easily obtained, but they are either too small to be cut into slices, or else are composed of a number variously aggregated. On the other hand fine crystals of the double chromate are readily formed.

R. C. B.

Contributions to the Study of Chemical, Geometrical, and Optical Isomorphism. (M. G. WYROUBOFF, *ibid.* No. 6)—A continuation of the essay on 's subject in the April number. The definition of isomorphism arrived that bodies are isomorphous when they have similar forms and unite portions which are not those of their atomic weights. The author

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has endeavoured to prepare mixtures of the chromates of potash and ammonia, by adding chloride of ammonium to potassic chromate, and also by neutralising bichromate of potash. But crystallisation proceeded with difficulty; with 11 to 13 per cent. of chromate of ammonia, the form of the crystals of chromate of potash did not change, but the optic axes diverged. With more ammonia, decided crystals are not obtained; with a still greater quantity—approaching the formula $CrO_4 K (NH_4)$—the crystals are clear and have quite a different appearance, but they are so macled as to be optically useless. From these facts it would appear that the combination belongs to two bodies exhibiting different geometrical forms, like the sulphates of potash and soda; and this is the case, for the chromate of ammonia is geometrically isomorphous with the sulphate of soda, not with the sulphate of ammonia. The chromate of ammonia is easily obtained, in crystals large enough to be cut into plates, by adding excess of ammonia to a hot concentrated solution of the bichromate of ammonia, and then cooling slowly. It is an unstable salt, quickly losing a molecule of ammonia, and becoming a bichromate. The crystals are in long needles, usually terminated at one end only by an obtuse pyramid, and exhibit a form identical with that of the anhydrous sulphate of soda. The combination of the chromate and the sulphate of ammonia takes place with difficulty; small macles are obtained, as in the case of the mixture with chromate of potash. From the geometrical isomorphism of the chromate of ammonia with the sulphate of soda, a combination of the chromates of soda and ammonia was tried, when a double salt with two molecules of water was obtained. The angle of the prism exhibits a striking analogy with that of the anhydrous sulphate of soda, and therefore with that of ammonic chromate. The four salts, the two anhydrous and the two hydrous, are perfectly isomorphous.

R. C. B.

On the Artificial Production of Minerals by Heat. (M. M. FOUQUE and MICHEL-LEVY, *ibid.*)—Experiments based on the consideration of eruptive volcanic matter, were made on the common silicates of volcanic rocks, by first melting the constituents of the silicate, and then lowering the temperature slightly below the fusing point. In this way the following were obtained: albite, oligoclase, labradorite, anorthite, nepheline, leucite, melanite, pleonast, magnetite, pyroxene, melilite. The Leucite exhibited roundish crystals resulting from the combination of the octahedron faces b' (112) with the dioctahedron a_3 (211) of the quadratic system; they had no action on polarised light. Attempts to produce orthose in a similar manner were unsuccessful. By operating with several grammes of material, the authors obtained the following associations, identical with

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those ejected by volcanoes:—labradorite with pyroxene and magnetite, and these last two with leucite (leucitite); and nepheline with pleonast and melanite. Many inclusions of gas-bubbles were obtained, especially in the crystals of labradorite, leucite, anorthite, and nepheline, similar in appearance, composition, and form, to those found in eruptive rocks. Negative crystals were abundant; those of anorthite exhibited the faces p (001), g' (010), m (110), t (110), and giving in section regular hexagons or parallelograms.

Some silicates were very refractory: thus black mica, Wernerite, and amphibole could not be obtained. On fusing the constituents of black mica, two substances were obtained, the one orthorhombic, brown, and somewhat dichroic; the other formed very long colourless microliths, strongly birefractive. The constituents of Wernerite (dipyre. 1, 2, 6), mixed with a trace of fluoride of sodium and fused, produced fine crystals of labradorite. Wernerite and amphibole from Odegaard near Bamle (Norway), similarly treated, produced an association of labradorite and pyroxene. A mixture possessing the composition of oligoclase with an excess of one-tenth of alumina gave rise to an association of many crystals of oligoclase, with a few of labradorite.

R. C. B.

An Artificial Crystallised Quartz. (M. M. FRIEDEL and SARASIN, *ibid.*)—Crystals of quartz have already been obtained by de Senarmont. who heated gelatinous silica in hydrochloric acid; by Daubrée, by the action of superheated water on glass; and by Hautefeuille, by heating silica to about 800° with tungstate of soda. The method adopted by the authors is to heat, to a temperature below dull red, a mixture of potash, precipitated alumina, and an excess of gelatinous silica in presence of water. At the expiration of 14 hours in one experiment, and 38 hours in another, nearly the whole of the silica was crystallised. In the first case a number of very small regular crystals were obtained, exhibiting only the hexagonal prism e^2 (10$\bar{1}$0) terminated by the double pyramid $p\,e^1 = (10\bar{1}1)$, (01$\bar{1}$1), and acting strongly on polarised light; the second time the crystals were much larger, and accompanied by small crystals connected together in masses and diverging from a central mass whose exterior was covered with hexagonal pyramids. They show all the characters of natural crystals, such as the striæ parallel to the intersections of p and e^1 with e^2, and the unequal development of the faces p and e^1. In an experiment in which somewhat less silica was present, some crystals were of the deformed variety termed *sphalloid* by Haüy. A description of the apparatus employed is appended to the paper.

R. C. B.

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On Mallardite. (M. A. CARNOT, *ibid.*)—In the Ecole des Mines are several minerals from Utah, and in one specimen were many fragments of an undescribed species,—a hydrated sulphate of manganese, analogous to that obtained in the laboratory by crystallisation at a low temperature. They were fibrous in structure; hyaline, and colourless, readily soluble in water, and very efflorescent. On heating, much water was given off, and then fumes of sulphuric acid, leaving a reddish-brown residue. Fused with carbonate of soda and nitre, a green mass was obtained, exhibiting the characters of a manganate. An aqueous solution of the mineral gives with basic salts the reaction of a sulphate; with sulphhydrate of ammonia a precipitate is thrown down, rosy, or grey to blackish, according to the greater or less absence of sulphate of iron. The results of two analyses are as follows:—

	I	II	OXYGEN.	
Sulphuric acid	26·0	29·0	17·40	=5·80×3
Protoxide of manganese ..	20·9	23·6	5·31	
Do. iron	0·3	—	—	=5·75×1
Magnesia	1·2	0·6	0·24	
Lime	0·8	0·7	0·20	
Water	36·8	44·5	39·55	=5.65×7
Insoluble residue	14·0	1·6		
	100·0	100·0		

The first was made by M. Rioult, of the Bureau d'essai, the second by the author on a carefully cleaned specimen. Formula = $Mn\,SO_4 + 7\,H_2O$.

Some minerals are known to contain sulphate of manganese, especially Apjohnite and Dietrichite, which are double sulphates of alumina and manganese, Fauserite (double sulphate of manganese and magnesia), and Szmikite, a sulphate of manganese with one equivalent of water. The mineral in question is a distinct and well-defined species, and the name Mallardite is proposed for it, after M. Mallard, the president of the French Mineralogical Society, by whom it is added that the mineral appears in the form of very transparent parallel fibres; those which could be isolated exhibit the prism *m* (110) with four faces modified by the faces *g'* (010); its crystallisation being probably oblique.

R. C. B.

An Artificial Dioxide of Manganese. (M. A. GORGEN, *ibid.* No. 5, May, 1879.)—On heating crystallised nitrate of manganese, it first melts, and then boils; decomposes at about 135°, and gives off nitrous fumes, leaving the pure dioxide. To obtain it in crystals the author decomposes the salt very slowly at a temperature of 155° to 162°, for 24 hours, in an oil or

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paraffin bath. The binoxide thus produced has the same properties as polianite, as to density, hardness, colour and crystallisation.

R. C. B.

On the Production of Caystallized Chromates. (M. L. BOURGEOIS, *ibid.*) —By a procedure similar to that adopted in his preparation of chromate of barium, the author has obtained the chromates of strontian and lime. The former presented fine yellow rhomboidal plates, with an angle of 101° 40′; cleavage parallel to the prism $m=(110)$; decomposed by a continued red heat and somewhat soluble in water. The chromate of lime formed fine yellow needles of a brilliant silky lustre, apparently right-angled. Slightly soluble in water, and more easily decomposed by heat than the preceding. By operating on equal portions of barium and strontium, or of barium and lime, the author has obtained double chromates in long prisms; with strontium and lime large tabular crystals were obtained, like those of the chromate of strontium. Hence the chromates of the alkaline earths are isomorphous one with another, and also with the corresponding sulphates, both as to form and composition.

R. C. B.

New Researches on Hopeite. (M. DAMOUR, *ibid.*)—This mineral, named after the Scotch chemist, Hope, was first described by Brewster, in the *Trans. Roy. Soc., Edin.*, 1824, but owing to its rarity, it has not hitherto been thoroughly analysed. The author, having had 2 mgrms. of it placed at his disposal, found that it is soluble in nitric acid without effervescence. On evaporating to dryness, it entirely dissolved in weak nitric acid. The liquid was then divided into two portions; the first, treated with ammonic molybdate, gave the greenish-yellow precipitate characteristic of phosphoric acid. Excess of ammonia, added to the second part of the solution, produced no precipitate, but ammonic hydrosulphide threw down sulphide of zinc of a blackish colour, owing to presence of iron. A long series of angular measurements is annexed.

R. C. B.

On the probable Identity of Microcline and Orthose. (M. A. MICHEL-LEVY, *ibid.*)—The association of these two minerals is remarkably intimate; they have the same chemical composition, and their crystals are very nearly alike. It has also been observed that the extinction produced by microcline between two crossed Nicols, in parallel rays, agrees with that of orthose. A demonstration, accompanied with a diagram, here follows, whence the author concludes that as all the other felspars extinguish the light in circumstances differing from those described, this agreement can hardly be regarded as accidental.

R. C. B.

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On the Optical Properties of Isomorphous Mixtures. (M. H. DUFET, *ibid.*)—The author states that in mixtures of isomorphous salts, the differences between the principal indices of the mixture and those of the component salts are in the inverse ratio of the number of equivalents of the two salts forming the mixture. If the equivalent of the compound salt be calculated, a straight line is formed by taking the equivalents for abscissæ and the indices for ordinates. By taking lengths proportional to the corresponding indices of the two salts on the lines perpendicular to the axis of x, and then joining the points representing the corresponding indices, straight lines are obtained which do not intersect; the plane of the axes does not alter, a condition which obtains in the mixture of the sulphates of zinc and magnesia studied by the author, and in the mixture of the chromate and sulphate of potash studed by M. Wyrouboff. Two of the lines can intersect, and then a uniaxal salt is obtained with a given composition, as is the case in the potash and ammonia salts of Seignette. One of the lines can intersect the two others, as happens in the mixture of the sulphates of potash and ammonia, and there are then two uniaxal salts.

R. C. B.

On some Crystallised Tungstates. (M. L. MICHEL, *ibid.*)—To obtain these the method of Geuther, Schultze, Forsberg, etc., was adopted, which consists of melting at a high temperature an alkaline tungstate (e.g. sodic tungstate), with a mixture of sodium and metallic chlorides. The fusion is conducted in a porcelain, contained in a Hessian crucible, the space between being packed with calcined magnesia. The mass is slowly cooled and then treated with water to extract the soluble chlorides. Crystals 1 cm. long and 1½ mm. wide were thus obtained. The proportions employed were:—1 part of tungstate of soda, 1½ of the metallic chloride, and two parts of sodium chloride,—the excess of this last giving larger and more regular crystals. By this procedure the author has obtained the tungstates of barium, strontium, calcium (Scheelite), magnesium, manganese (Hubnerite), iron, iron and manganese (Wolfram), cobalt, nickel, zinc, cadmium, copper, and lead (Stolzite); also the tungstate of bismuth (not hitherto obtained), in greenish-white nacreous plates.

R. C. B.

Boracite. (*Ibid.* No. 6, June.)—In an abstract from a late number of the *Zeitschrift für Krystallographie* (Vol. III, No. 4), it is stated that M. Baumhauer has studied the crystallisation of this substance, as developed by corrosion-figures, whence he has deduced that it is orthorhombic, and that the cubic form is due to an assemblage of six orthorhombic crystals, constituting as many pyramids, and having the cubic faces as their bases.

R. C. B.

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Minerals occurring at Sarrabus (*Sardinia*), *ibid.*—In a communication from M. Traverso, it is stated that veins of silver and lead ores are being worked at this place; they occur in granitoid porphyries, amphibole-quartzite, with pyrrhotine, and black schists with pyrite and calcareous veins. The gangue consists of calcite, fluor, baryte, quartz, and steatite. Associated minerals are: native silver, argentite, *argent fragile* or psaturose, red silver (argyrithrose), galena, blende, copper pyrites, grey copper (tetrahedrite), molybdate of lead (wulfenite), carbonate of lead, Breithauptite, harmotome, gypsum, dolomite, and Aragonite.

R. C. B.

On Breislakite. (The same, *ibid.*)—This was observed as brownish filaments on a druse of tridymite, amongst crystals of hypersthene, from the sanidine-trachyte of the Roc du Capucin, Mont Dore. They had an appearance identical with those of the trachyte of Monte Olibano.

R.C.B.

On the Composition of Hopeite. (M. M. FRIEDEL and SARASIN, *ibid.*) —The authors have succeeded in producing a substance with the crystalline and optical properties of this mineral. Oxide of zinc was mixed in various proportions with a dilute solution of phosphoric acid, and the whole heated in closed tubes at from 150° to 180° for about 16 hours. The contents became crystalline, and under the microscope exhibited crystals apparently orthorhombic, together with others in triangular plates. As these last became more numerous with a greater amount of phosphoric acid, it was increased till its weight equalled that of the oxide of zinc, when the product became free from orthorhombic prisms. Tabular crystals were thus obtained, rectangular or six-sided, and symmetrical, the smaller sides of the rectangle disappearing through the replacement of the angles with obtuse slopes. These sloping sides contain an angle of about 150°; the angle of the faces a^3 a^3 of Hopeite is 149° 16′ (Levy.) Measured with the goniometer, it was found that the angle of the faces $m\,m = 120°$, $m\,g' = 120°$; those of Hopeite are 120° 26′ and 119° 47′. The optical properties are also similar. In parallel polarised light, the planes of extinction are parallel to the sides of the rectangles. With converging light, there is a disposition of symmetrical colours, and with plates sufficiently thick, there is an appearance of the neutral lines indicating that the plane of the axes is parallel to the base of the prism. On analysis, these artificial crystals gave:—

Phosphoric acid	31·12	31·07	Theory.
Oxide of zinc..	53·52	53·18	
Water	14·45	15·75	
	99.09		

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Formula = P_2O_5, 3Zn O, 4 H_2O. Only two molecules of water are given off at 100°. Hopeite is therefore very probably a tribasic phosphate of zinc.

R. C. R.

On Artificial Libethenite. (The same, *ibid*)—It has been shown by Debray that this substance is obtained, as a crystalline powder, when the tribasic phosphate of copper, P_2O_5, 3 CuO, 3 H_2O, is heated with water in sealed tubes. The boiling temperature is sufficient to change the tribasic phosphate into greenish-white crystalline Libethenite. To obtain fine crystals, it is necessary to employ a closed vessel at about 180°, with an excess of phosphoric acid. Olive-green crystals were thus obtained, exhibiting the faces *m* and *a'*; the angles found were, *m m* = 87° 30', *a' a'* = 70°—71°; in Libethenite, *m m* = 87° 40', *a' a'* = 70° 8'. When either the natural or the artificial mineral is reduced to powder, and ignited at a red heat in a test-tube, or on platinum in the Bunsen flame, water is given off, and a substance results which is brown while hot, and of a fine green when cold.

Olivenite, which much resembles Libethenite, gives merely a brown powder on calcination.

R. C. B.

On the Preparation of a Felspar. (The same, *ibid.*)—By using the apparatus employed in their production of artificial quartz, and a mixture composed of the silicates of alumina and potash, together with a small quantity of caustic potash, the authors obtained a crystalline powder after heating the mixture to a dull red for 36 hours. This powder behaves under the blowpipe like felspar, and fuses with difficulty to a white glass. Its density is the same as that of orthose. Analysis showed that a felspathic matter was obtained, viz.:—

		ORTHOSE	POTASSIC PETALITE.	
Silica	72·0	64·63	calculated	70·90
Alumina	14·9	18·49		15·21
Potash	12·2	16·87		13·83

The result agrees with a mixture of orthose and quartz, or a felspar rich in silica, analogous to petalite, and mixed with a small quantity of quartz.

R. C. B.

Epistilbite. (M. des Cloiseaux, *ibid.*)—From an examination, with the micro-polariscope, of more than two dozen cleavage-plates of specimens from Berufjord and Ofjord, the author finds that there exists in them a

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twin-plane tangent to the obtuse edge $\frac{m}{m}$. He concludes that it should be considered as belonging to the clinorhombic system, and remarks on the necessity of new and exact measurements.

R. C. B.

On a Chromiferous Garnet from the Pyrenees. (M. A DAMOUR, *ibid.*)—This mineral forms an essential part of a crystalline rock of a pale-green colour, containing calcite, quartz, and a white mineral, very fusible under the blowpipe, and exhibiting a relation to Wernerite or Zoizite. By acting on this rock with dilute nitric acid, the calcareous part is dissolved and small druses are set free, in which the green garnet appears crystallised as rhomboidal dodecahedra. This mineral, being variously fissured, is easily broken, retaining the hardness of the garnets = 6 to 7; spec. grav. = 3·43. Melts with difficulty before the blowpipe to a black glass, not magnetic; with borax or microcosmic salt it gives an emerald-green glass. The analysis was as follows:—

			OXYGEN	RATIO.
Silica	36·20		19·30	2
Alumina	10·20	4·75		
Chromic oxide	6·50	2·04	9·67	1
Ferric ,,	9·60	2·88		
Ferrous ,,	8·16	1·81		
Manganous oxide	0·50	0·13	9·79	1
Lime	27·50	7·85		
	98·66			

whence the formula = 3 (CaO, FeO, MnO) + (Al_2O_3, Fe_2O_3, Cr_2O_3) + 3 SiO_2. This analysis agrees with that of a chromiferous garnet from Orford (Canada), as found by Mr. Sterry Hunt. There is not enough oxide of chromium to connect it with Uwarowite, but it seems rather to be a variety between Uwarowite, almandine, and melanite. The mineral described was found near Venasque, on the Pic Posets, near Maladetta.

R. C. B.

On Venasquite. (By the same, *ibid.*)—This mineral, so called from being found near Venasque, was first described by M. N. Boubée in 1857, referred by him to Ottrellite. It occurs in crystalline masses, lamel- and radiated; in colour it is greyish-black, powder grey. H = 5·5. 3·26. Heated in a tube, a little water is given off. Under the blow-, the thin edges melt with difficulty on platinum; on charcoal, a black ia is formed, slightly magnetic; microcosmic salt gives the reaction of

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iron, with a silica skeleton. Not attacked by acids. Analysis gave the following result:—

		OXYGEN.	RATIO.
Silica	44·72	23·89	6
Alumina..	29·71	13·84	3
Ferrous oxide.. ..	20·75	4·61 } 4·85	1
Magnesia	0·62	0·24 }	
Water	4·93	4·38	1
	100·80		

giving a formula=(FeO, MgO) Al_2O_3, 3 SiO_2+H_2O; while that of Ottrelite from Luxemburg is=3 (FeO, MnO) 2 Al_2O_3 6 SiO_2+3 H_2O, the manganese being sufficient to form a distinctive character.

R. C. B.

On Luckite. (M. A. CARNOT, *ibid.*)—In some specimens of the Mallardite from the "Lucky-Boy" silver mine, Utah, occur many crystals of hydrated sulphate of iron containing manganese; they are clear and of a bluish tinge, and form furrowed prisms, irregular and somewhat twisted. Both in the dry and wet way, they give all the reactions of hydrated sulphate of iron, or melanterite, but manganese is also present. The result of analysis was:—

		OXYGEN.	
Sulphuric acid	26·3	15·78	=5·26×3
Ferrous oxide	21·7	4·80	
Manganous oxide ..	1·9	0·43	=5·45×1
Magnesia	0·2	0·08	
Lime	0·5	0·14	
Insoluble residue.. ..	7·2		
Water (by diff.)	42·2	37·55	=5·36×7
	100·0		

when the formula is SO_3, FeO, MnO+7 H_2O, in which the proportion of manganese is about one-tenth that of iron. The mineral would seem to occupy a position between melanterite and Mallardite; but on exposure to the air it does not effloresce, like the latter, nor exhibit an ochreous colour like the former. It constitutes a manganiferous variety of melanterite, and the name Luckite, from the place of its occurrence, is proposed for it.

R. C. B.

Szaboite. (A. VON LASAULX and A. KOCH, *Zeit. für Kryst. und Min. III*, 3, pp. 288 and 307.)—This mineral is known to occur in four localities: Aranyer Berg, Transylvania (Koch); Monte Calvario at the

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foot of Etna (von Lasaulx); in a trachyte of the Riveau Grand, Mont Dore (Gonnard); and lastly on lava at Monte Corvo, near Biancavilla. The specimens from the last two places are chocolate-brown; those from Mont Dore (Puy de Dome) have the yellow colour of certain sphenes, while those from Monte Corvo are of a greyish colour.

The crystals hitherto met with are figured in Pl. XIII, figs. 3 to 5. See also *Min. Mag.*, Vol. II, p. 248.

R. C. B.

Correspondence.

Montreux, March 6th, 1880.

To the Editor of the Mineralogical Magazine.

Sir,—I propound the following as a problem, as specially suitable for the attention of Cornishmen, since they live near the sea, and can no doubt obtain the use of suitable instruments.

Measure the angles of crystals, fixed on the axis of the moveable limb of

I.—A Bordas circle.

II.—A Theodolite.

Very truly yours,

MARSHALL HALL.

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ERRATA, Vol. III.

Page 162, line 6 from top, for "it" *read* "to."
„ 162, „ 9 „ foot, for "was" *read* "were."
„ 172, „ 22 „ top, for "flat, beach-covered, for" *read* "flat beach, covered for."
„ 177, „ 4 „ foot, for "SHAPINTHAY" *read* "SHAPINSHAY."
„ 210, „ 21 „ top, for "pyrargyrite" *read* "pyrargillite."
„ 177, „ 10 „ „ for "aca" *read* "arca."
Same line for "water-worm" *read* "water-worn."

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PROCEEDINGS.

OF THE

MINERALOGICAL SOCIETY OF GREAT BRITAIN AND IRELAND.

1879.

EXCERPT MINUTES OF COUNCIL MEETING

Held at 116, *Victoria Street, London, June 3rd,* 1879.

PROFESSOR T. G. BONNEY, M.A., in the Chair.

The voting papers having been examined, it was

Resolved—That the following gentlemen be elected to complete the list of Corresponding Members,—

PROF. BRUSH, Newhaven.
PROF. B. VON COTTA, Freiberg.
PROF. DAUBREE, Paris.
PROF. DESCLOIZEAUX, Paris.
PROF. DELESSE, Paris.
PROF. GEINITZ, Dresden.
PROF. F. VON KOBELL, Munich.
PROF. RAMMELSBERG, Berlin.
PROF. G. VOM RATH, Bonn.
PROF. RENARD, Brussels.
PROF. ROSENBUSCH, Berlin.
PROF. F. SANDBERGER, Wurzburg.
PROF. TSCHERMAK, Vienna.
PROF. F. ZIRKEL, Leipzig.

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The following ordinary members and associates were also declared duly elected.

ORDINARY MEMBERS.

CAPT. DOWLER, 60, Maddox Street. London, W.
MR. S. FRANCIS BAWDEN. Rio Tinto Mines, Spain.
REV. J. E. SOMERVILLE, Broughty Ferry.
MR. COLIN B. PHILLIPS, St. Andrews.
MR. SAMUEL HENSON, Strand, London.
MR. J. P. HOWLEY, St. John's, Newfoundland.

ASSOCIATES.

Mr. GEO. F. TREGELLES, Falmouth.
Mr. R. J. CUNNACK, Helston.

Resolved—That the Annual Meeting be held at Sheffield, on Friday, August 22nd.

GENERAL MEETING,

Held at 116, *Victoria Street, London, W.*

PROFESSOR T. G. BONNEY, M.A., in the chair.

The following papers were read and discussed :—

On Abriachanite—a new Scottish mineral, by Prof. Heddle and Dr. W. H. Aitkin.

On Haughtonite—a new Mica, by Prof. Heddle.

On Bhreekite and Xantholite, by Prof. Heddle.

On some Gold Occurrences, by Rev. J. Clifton Ward.

Minerals from Japan, by John Milne.

On Christophite, from St. Agnes, Cornwall, by J. H. Collins.

Additional note on Penwithite, by J. H. Collins.

Measurements of Angles of Basaltic Columns at the Giant's Causeway, by Prof. J. H. Jellett and Prof. O. Reilly.

Specimens in illustration of their papers were exhibited by Prof. Heddle and Mr. J. H. Collins.

Mr. J. R. Gregory exhibited some fine Chalcedonic Geodes enclosing fluid, from Salto Chico, Dagracto Salto, Uruguay.

The Secretary announced that Dr. Heddle's large Geological and Mineralogical Map of the Shetland Islands was in the hands of the mounter, and would be issued to the Members as soon as completed.

Thanks were voted to Mr. R. H. Scott for the use of his office on the occasion of the meeting.

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BOOKS RECEIVED TO JULY.

From *Prof. J. D. Dana*, Newhaven. American Journal of Science.—May and June.

„ *Academy of Sciences*, Philadelphia. Proceedings 1878.

„ *Reale Comitato Geologico*, Rome. Bolletino 3 and 4, 1879.

„ *Prof. Groth*, Strasburg. Zeitschrift fur Kryst. und Min. Band III. Heft 4.

„ *Rev. S. Haughton*, Dublin. The Mineralogy of Dublin and Wicklow.

„ *G. H. Kinahan*. Quartzyte (Quartz Schist) and Quartz Rock (Greisen).

„ *J. H. Collins*, Truro. The Trelissick Elvan, by J. H. Collins.

„ „ „ The Elvan Courses of Cornwall, by A. K. Barnett.

„ „ „ The Elvan Courses of Cornwall, by W. H. Argall.

„ „ „ A Deposit of Tin in the Park of Mines, by Dr. C. Le Neve Foster.

„ *Rev. J. C. Ward*, Keswick. The Physical History of the English Lake District, by J. C. Ward.

„ *Prof. Sandberger*. Beiträge zur Kenntniss der am Bauersberge bei Bischofsheim, by Sigmund Singer.

„ *Prof. G. Tschermak*, Vienna. Mineralogische und Petrographische Mittheilungen, Band II, Heft 1 and 2.

„ *Prof. Delesse*, Paris. Notice sur les Titres Scientifiques, de M. Delesse.

„ „ „ Le fond des Mers, Etudes lithologiques, by M. Alexis Delaire.

„ „ „ Gisement et exploration du Diamant dans la Province Minas Geraes au Brasil, by Ch. Bensser and G. Claraz, abstracted by M. Delesse.

„ „ „ Memoire sur la constitution Minéralogique et Chimique des roches des Vosges, by M. Delesse.

„ „ „ Sur les gisements de Chaux Phosphatée de l'Estramadure, by M. Delesse.

„ „ „ Rapport sur un Mémoire de M. Delesse intitulé "Etude des déformations subies par les terrains de la France." Presented to the Academy of Sciences by Messrs. Elie de Beaumont, Ch. St. Claire Deville, and Daubrée, 1872.

„ „ „ Cours d' Agriculture professé par M. Delesse, Ecole Nationale des Mines, 1877-8.

„ „ „ Sur le porphyre de Lessines, by M. Delesse.

„ „ „ Ueber die Menge des dems Kalkspath von Fontainebleau beigemengten Sandes, by M. Delesse.

„ „ „ Lithologie des Meere der Alten Welt, by M. Delesse, translated by Herr Hanchecorne, Berlin.

„ „ „ Cartes Géologique et Hydrologique de la Ville de Paris, by M. Delesse.

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Books received to July (continued).

„ *Prof. Delesse*, Paris. Sur les Rapports Cristallographiques et Chimiques de l' Augite de l' Hornblende et des Minéraux analogues, par M. C. Rammelsberg; translated by M. Delesse.

„ *Prof. G. Vom Rath*, Bonn. Ueber das Gold, von Prof. G. von Rath; Sammlung gemeinverständlicher wissenschaftlicher vorträge XIV Serie, Heft 324 and 325.

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EXCERPT MINUTES OF COUNCIL MEETING.

Held at the Masonic Hall, Sheffield, on Friday, August 22nd, 1879.

H. C. Sorby, F.R.S., in the Chair.

The following gentlemen were elected as Ordinary Members,—

Mr. S. Gorman Burn, of Central City, Kansas, U.S.A.
Mr. W. R. Hodgkinson, of the Royal College of Chemistry, South Kensington.

The Report of the Council as drafted by the Secretary was modified and approved.

FOURTH ANNUAL GENERAL MEETING,

Held at the Masonic Hall, Sheffield, on Friday, August 22nd, 1879,

H. C. Sorby, F.R.S., in the chair.

The following Report was read by the Secretary.

COUNCIL REPORT, 1879.

Once more we have the pleasure of congratulating the Members on the continued prosperity of the Mineralogical Society, notwithstanding the losses which it has sustained by deaths and by withdrawals. During the year which is just concluded, 14 corresponding members, 16 new ordinary members, and 6 associates have been elected; on the other hand the Society has lost four members—Professors Harkness and Nicol, Mr. Wm. Vivian, and Mr. W. R. Williams,—by death; and several members by removal or withdrawal. The present strength o the Society is as follows:—

Corresponding Members	24
Ordinary Members	124
Associates	24
	172

The corresponding number last year was 163.

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Our financial position is good, as was shewn by the balance sheet lately issued in the Magazine. This shews a balance of assets over liabilities amounting to £85 10s. 11d, besides a sum of £118 3s. 0d., invested in 3 per cent. Consols; together amounting to £203 13s. 11d. The corresponding balances last year amounted to £144. The credit balance is exclusive of the value of the considerable stock of Magazines in hand at the end of 1878.

The second volume of the Mineralogical Magazine has been completed since our last annual meeting. It is even more valuable than its predecessor, although the council has still to regret that the contributors to its pages of original papers are so few. The Society is especially indebted to Professor Heddle for his valuable papers on the Mineralogy of Shetland, and for his excellent Geological and Mineralogical Map of the Shetland Islands.

Dr. H. C. Sorby now retires from the Presidential chair, after more than three years of most valuable service, but the Council will still have the advantage of his advice and assistance as the first of its past Presidents.

We have now to recommend the election of Dr. M. Forster Heddle, of St. Andrews, as his successor.

His election will vacate one of the Vice-Presidental chairs, and we propose as his successor, Prof. T. G. Bonney, of St. John's College, Cambridge. Messrs. Church, Drew, Duncan, and Archibald Geikie retire by rotation from the Council, and the election of Prof. Bonney as Vice-President will create a fifth vacancy.

To fill up these vacancies we propose the election of the following gentleman as Members of Council.

Mr. R. H. Scott.
Dr. Thos. Aitken.
Prof. T. Mc. Kenny Hughes.
Prof. Alexr. Crum Brown.
Mr. T. W. Miller.

For the remaining offices we propose the re-election of Dr. C. Le Neve Foster, as Foreign Secretary; Messrs. F. W. Rudler, and B. Kitto, as Auditors; and Mr. J. H. Collins, as Secretary.

By the gifts of Members, and by exchanges with kindred bodies, the Society is gradually accumulating a valuable Mineralogical and Petrological Library. A List of the books which are now available for the use of Members—and which may be obtained on application being made to the Secretary—will be published in an early number of the Mineralogical Magazine.

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In conclusion we would again urge all Members and Associates to use their influence to increase the numbers and promote the prosperity of the Society.

The report was adopted, *nem. con.*

The following papers were read—

On the production of different secondary forms of crystalline minerals, by H. C. Sorby, F.R.S.

On some Peridotic rocks from the island of St. Paul's, by Rev. A. Renard.

On some Cornish Serpentinous rocks, by J. H. Collins, F.G.S.

On some old Rhyolites from Jersey, by T. Davies, F.G.S.

On some artificial crystals isomorphous with Olivine, by A. E. Arnold. Communicated by J. H. Collins, F.G.S.

Remarks on the Minerals of Cyprus, by J. H. Collins, F.G.S.

The following papers were taken as read—

On the Minerals of the Hornblendic Gneiss of Sutherland, by Prof. M. F. Heddle.

On some Minerals from the Mawddach Valley, North Wales, by T. A. Readwin, F.G.S.

On a curious form of Coal from South Wales, by Jas. S. Merry.

The meeting was concluded with cordial and unanimous votes of thanks to the proprietors of the Masonic Hall for the use of the meeting room, and to Dr. Sorby for his conduct in the chair.

BOOKS RECEIVED.

From *Prof. J. D. Dana*, Newhaven. American Journal of Science.—July to October, 1879.

„ *Prof. D'Achiardi*, Pisa. Atti della Soc. Tosc. di Sci. Nat., Vol. IV. fasc 1.

„ „ „ Atti della Soc. Tosc. Proc. Verb. LXXXIX to CXXXI.

„ *Prof. Rammelsberg*, Berlin. Ueber das Verhalten fluorhaltiger Mineralien in hoher Temperatur, inbesondere der Topase und Glimmer.

„ „ „ „ Ueber die Zusammensetzung der Lithion-glimmer.

„ *Prof. Tschermak*, Vienna. Min. und Pet. Mittheilungen, Band I, Heft 1 to 6.

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EXCERPT MINUTES OF COUNCIL MEETING,

Held at 116, *Victoria Street, October* 21*st*, 1879.

Prof. M. F. Heddle, F.R.S.E., President, in the Chair.

The Secretary reported the death of Prof. B. von Cotta, one of the corresponding members of the Society, when it was

Resolved:—That the Foreign Secretary be requested to write a letter of condolence to the family of the late Professor.

The following resolutions were also passed *nem: con.*

Resolved:—That Prof. Sella be elected a corresponding member of this Society in place of the late Prof. B. von. Cotta.

Resolved:—That Mr. Collins be requested to continue to edit the Magazine for the forthcoming year, and to accept of the honorarium of Twenty Pounds.

Mr. Henry Louis, Assoc. R.S.M. of Derwent House, Derwent Road, Anerley, was elected as an ordinary member. Mr. James Smith, of Bridge Street, Manchester, was elected as an Associate.

GENERAL MEETING.

Held at 116, *Victoria Street, London, W., October* 21*st*, 1879.

Prof. M. F. Heddle, F.R.S.E., President, in the Chair.

The Minutes of the Sheffield Meeting were read and confirmed, and the President expressed his thanks to the members for his election.

The following papers were read and discussed—

On the Mineralogy and Geognosy of the Orkney Islands, Part I., by the President.

On a probably Dimorphous form of tin, and on some crystals found associated with it, by Dr. C. O. Trechmann and Mr. J. H. Collins.

On a peculiar pasty form of Silica from a cavity in gold-bearing quartz by Mr. A. French.

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On some Cornish Tin-stones and Tin-capels, by Mr. J. H. Collins.

Experiments on the Elasticity of Crystals, by Prof. John Milne.

Mr. Watson, of Pall Mall, exhibited and explained his new Microscopes for Petrological research.

A vote of thanks was passed to Mr. R. H. Scott for his kindness in permitting the use of his rooms for the Meeting.

BOOKS RECEIVED.

From *Prof. Jas. D. Dana*, Newhaven. American Journal of Science.—November and December, 1879.

„ *Prof. D'Achiardi*, Pisa. Atti della Soc. Tosc. di Sci Nat. Proc., Verb. Vol. II. pp. 1-16.

„ *Prof. Groth*, Strasburg. Zeit. für Kryst. und Min. Band IV, Heft. 2.

„ *Soc. Geol. de Belg.* Liege. Annales, tome V. 1877-8.

, *Reale Comitato Geologico*, Rome. Bolletino, 9 and 10, 1879.

„ *Soc. Cientif. Argentino*, Buenos Ayres. Annales, September to November, 1879.

„ *A. W. Howitt*, Gippsland. The Diorites and Granites of Swifts Creek. and their contact zones, with notes on the auriferous deposits.

„ *F. R. Mallet, F.G.S.* On Corundum from the Khâsi Hills.

„ „ On Mysorin and Atacamite from the Nillore District.

„ *A. Damour*, Paris. Sur une obsidienne de l'Inde qui a éclaté avec detonation au moment où on la sciait.

„ „ Note sur un moyen de rèsoudre synthetiquement plusieres des principales questions de cristallographie, by G. Delafosse.

„ , Géogénie des minerais calaminaires de zinc, plomb, et fer en gites irréguliers, by M J. Delanoüe.

„ „ Sur la densité de quelques substances (quartz, coryndon, metaux, &c.,) apres fusion et refroidissement rapide, by M. Charles St. Clair Deville.

„ „ Note sur la double réfraction artificiellement produite dans des cristaux du systeme regulier, by M. Wertheim

„ „ Sur l'Apatite, la Wagnerite et quelques especès artificielles de phosphates métalliques, by M. M. St. Clair Deville and H Caron.

„ „ Sur les soufflures de l' Acier, by H. Caron.

„ „ Report on a Memoir by M. Hugand, entitled "Etude cristallographique de la strontiane sulfatée.

P. H Argall. Notes on Ancient and Recent Mining Operations in the East Ovoca District.

M. D'esse, Paris. Explosion d' acide carbonique dans une mine de houille.

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LIST OF BOOKS RECEIVED TO MARCH, 1880.

From *Soc. Min. de France*, Paris. Bulletin, Vol. II. Nos. 7 & 8, Vol. III. Nos. 1 & 2.
„ *Soc. Cient. Argentina*, Buenos Ayres. Anales, Vol. VIII, Dec. 1879. Vol. IX
„ *Prof. Tschermak*, Vienna. Min. und Pet. Mitt. II, 5.
„ „ *Jas. D. Dana*, Newhaven. American Journal of Science.—January to March, 1880.
„ „ *Groth*, Strasburg. Zeitschrift für Kryst. und Min., Band IV, Heft. 2.
„ *J. P. Howley*, Newfoundland. Reports of the Geological Survey of Newfoundland, 1870 to 1878, inclusive.
„ *Henry Louis*, London. Contributions to the Mineralogy of Nova Scotia.
„ *Prof. Johnstrupp*, Copenhagen. Giesecke's Mineralogiske Rejse i Grönland, by F. Johnstrupp.
„ „ „ Meddelelser om Grönland, Förste Hefte.
„ „ *G. vom Rath*, Bonn. Vorträge und Mittheilungen, 1880.
„ „ *D'Achiardi*, Pisa. Atti' del Soc. Tosc. Proc. Verb. 17 to 36, 1880.
„ *W. Whitaker, B.A.* List of Works on the Geology &c. of Cornwall, by W. W.
„ „ List of Works on the Geology, Mineralogy, and Palæontology of Cheshire. by W. W.
„ *Prof. A. Liversidge*, Sydney. Report of the International Congress of Geologists at Paris in 1878, by A. L.
„ „ „ On the occurrence of Chalk in the New Britain Group, by A. L.
„ „ „ On some New Zealand minerals in the Otago Museum, by A. L.
„ *Royal Society of New South Wales*, Sydney. Journal and Proceedings, 1878.
„ „ „ „ „ Annual Report of the Department of Mines of New South Wales, 1877.
„ *Prof. von Kobell*, Munich. Tafeln zur Bestimmung der Mineralien, Elfte vermehrte Auflage, by F. v. K.
„ „ „ „ Die Mineraliensammlung des Bayerischen Staates, by F. v. K.

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LIST OF WORKS IN THE LIBRARY

OF THE

MINERALOGICAL SOCIETY,

*AND AVAILABLE FOR THE USE OF MEMBERS.**

ENGLISH, AMERICAN, AND COLONIAL.

Mineralogical Magazine, Vols 1 to 3, 1877-1879.
American Journal of Science, Vols. 13 to 18, 1877 to 1879.
Reports of the Geological Survey of Newfoundland, 1870 to 1878.
Reports of the Department of Mines, Nova Scotia, 1876 to 1878.
Reports of the Department of Mines, New South Wales, 1876 & 1877.
Journal and Proceedings of the Royal Society of New South Wales, 1875 to 1878.
Transactions of the Philosophical Society of New South Wales, 1862 to 1865.
Fuch's Determination of Minerals by the Blowpipe, translated by T. W. Danby.
The Mines and Mineral Statistics of New South Wales, 1875.
Clarke on the Sedimentary Formations of New South Wales, 1878.
How on the Mineralogy of Nova Scotia.
The Railways of New South Wales, 1876.
Milne, J. on Crystallography.
Portlock's Geological Report on Londonderry and Tyrone.
Proceedings of the Academy of Natural Sciences, Philadelphia, 1877 and 1878.

MISCELLANEA, Vol. 2.

Liversidge on the Minerals of New South Wales.
,, on a remarkable example of contorted slate.
,, on a fossiliferous siliceous deposit from the Richmond river New South Wales.
Howitt on the Diorites and Granites of Swift's Creek.
New South Wales: its progress and resources, 1876 and 1877.
Argall. Notes on Mining Operation in the East Ovoca District.
Ward. Physical History of the Lake district.
Liversidge. Formation of Moss-Gold and Moss-Silver.
Kinahan. Quartzyte and Quartz Rock.
Collins, on the Trelissick Elvan.
Argall, on the Elvan Courses of Cornwall.
Barnett, on the Elvan Courses of Cornwall.
Bennetts, S. Remarks on Metalliferous Veins.
Garland, J. Phosphorite Mining in Nassan.
Collins, J. H. Underground temperature at Dolcoath.
,, ,, Note on the Rocks and Goonbarrow Mines.
Foster, C. Le Neve. A Deposit of Tin in the Park of Mines.
Haughton, S. Mineralogy of Dublin and Wicklow.
Burghardt, C. A. Origin of some Ores of Copper.
Nordenskjold, A. E. Expedition to Greenland.
Johnson, M. H. Flint.

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*By application to the Secretary in writing.

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FRENCH AND GERMA .

Annales de la Soc. Géologique de Belgique, 1874 to 1878.
Bulletin de la Soc. Min. de France, 1878 and 1879.
Groth's Zeitschrift fur Kryst. und Min., vols. 1 to 3.
Tschermak's Min. und Pet. Mittheilungen, 1878.
Vom Rath. Natur wissenschaft. studien, 1878.
,, ,, Vortrage und Mittheilungen, 1879.
Von Kobell. Tafeln zur Bestimmung der Mineralien.
,, ,, Die Mineraliensammlung des Bayerischen Staates.
Miscellanea, Vol. 1.
Rammelsberg, M. C. Sur les Rapports de l'Augite, de l'Hornblende, et des mineraux analogues.
Delaire, A. Le fond des mers, étude lithologiques.
Delesse. Cartes geologique et hydrologique de la Ville de Paris.
,, Sur le porphyre de Lessines. Sur les gisements de chaux phosphatée de l'estremadure.
,, Heusser et Claraz, Gisement et exploitation du diamant dans la Province minas geraes Brésil.
,, Sur un cours d' agriculture.
,, Sur la constitution minéralogique et chimique des roches des Vosges.
Trechmann, C. O. Beiträge zur Kenntniss des Turnerit.
Sadebek. Uber die Krystallization des gediegenen Silbers.
Sandberger. Uber das Vorkomenen des Zinns in Silicaten.
Rammelsberg. Uber Markasit.
Delesse. Uber die menge des dem Kalkspath von Fontainbleau.
,, Lithologie des Meere der alten welt.
Vom Rath. Uber des "Report of the U.S. Geol. exploration of the 40th parallel."
,, Uber Famatinit, &c.
,, Hannayit, Newberyit, &c.
,, Uber das gold.
,, Uber das Verhalten fluorhaltiger, Mineralien in hohen temperatur.
,, Uber die Zusammensetznng der Lithionglimmer.
Singer. Beiträge zur Kenntnis der am Bauersberge bei Bischofsheim vor der Rhön.

ITALIAN, SPANISH, &c.

Reale Comitato Geologica d'Italia, 1877 to 1879.
Atti di Soc. Nat. Scienze, Pisa, vol. III, 1877-8, vol. IV, 1879.
Anales de la Societad Cientifica Argentina, vol. VIII.

NORWEGIAN, DANISH, &c.

Kjerulf. Udsigt over det sydlige norges geologi, 1879.
Johnstrupp. Giesecke Mineralogiske Rejse i Gnrland.
Meddelelser om Grönland.

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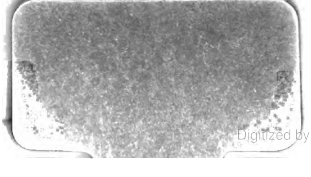

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